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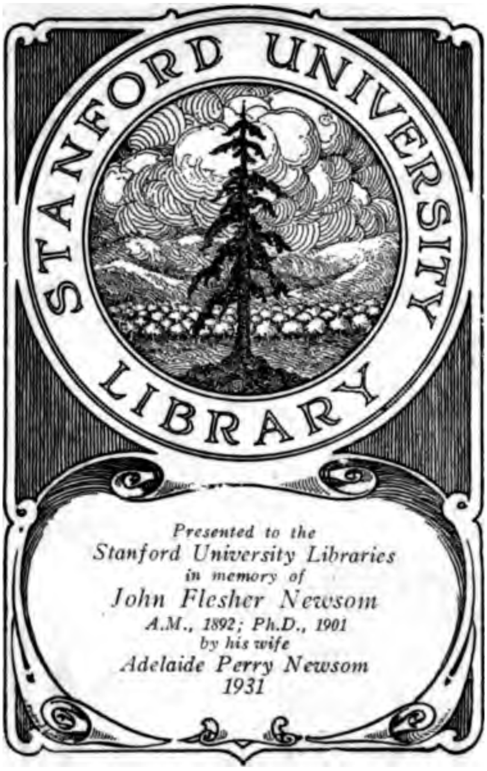

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Gold Dredging.

I.—Introduction.

LITTLE advantage would result from narrating the history and evolution of dredging for gold, or from describing, in detail, the obsolete machines designed for this purpose. A brief enumeration of these latter, however, may serve to mark the failures of inventors in the past, and thus warn their successors against similar attempts. Under the heading of obsolete machines may be classed the pneumatic caisson, the submarine boat, the hydraulic elevator, and the vacuum dredge. The pneumatic caisson was on the principle employed in sinking cylinders for the piers of bridges. In it, the diver was let down so as to work direct on the bed of the river. This might be all right for a rich patch, the situation of which was exactly known; but, for every-day work, where much barren stuff had to be lifted, it proved a lamentable failure. A submarine boat, on the principle of the diving bell, is said to have been constructed, but never used. Dredging operations using the principle of the hydraulic elevator were attempted on the Chestatee River, Lumpkin co., Ga., but proved unsuccessful, the elevator being out of place in a river bed, many feet below the level of the water, since most of its work consisted in raising water that did not contain gold. The Bazin dredge was one of the first worked on the vacuum system. The principle upon which the vacuum in this machine was obtained lay in the difference of level between the water outside and the bottom of the hull, in consequence of which the water was forced up the suction-pipe projecting down from the hull to the river bed, and in doing so carried up the auriferous sands. A centrifugal pump received all the matter forced into the tube, and, adding fresh impulse to its progress, delivered it to the washing appliances. A disadvantage of this form of dredge was that it required a considerable depth of water in order to produce the requisite amount of vacuum for efficient work. This defect led to the introduction of steam vacuum dredges. The boat was fitted with a boiler and steam pump, each connected with a vacuum chamber, from which projected the suction pipe resting on the river bed. To operate the machine, steam was let into the vacuum chamber, expelling the air through a self-closing valve. A jet of water was then sprayed in, the steam condensed, and a vacuum formed, into which the water, sand, and gravel rushed through the sand pipe and entered the chamber. A discharge door was then opened, and the contents delivered into the sluice. As atmospheric pressure governs the operation, and this pressure is 14.7 lbs. to the square inch, it is evident that such a form of dredge lacks the power and capacity required in modern dredging. The experience gained from these and similar appliances, added to increased mechanical facilities, speedily resulted in the designing of more practical dredges, which, under the type of the "dipper," the "suction," the "grab," and the "bucket ladder," find their application in modern dredging.

II.—The Dipper, Spoon, or Shovel Dredge.

In its primitive form, the dipper dredge consists of a barge or pontoon, to the side of which is attached a long pole carrying a strong canvas or hide bag, or iron bucket, which is termed a ladle, spoon, scoop, or dipper, and which at times is provided with a blade or shovel. To the dipper end of the pole, is fastened a rope or chain, carried back to a hand-winch in the dredge, by which means the dipper is raised. In working, the dredge is moored in the stream, the dipper is lowered, drawn along the bottom, and then raised by the winch. The operation is slow and laborious, and even under the most favourable conditions cannot raise more than 2 or 3 tons of gravel per hour. Nevertheless, in the early days of gold-dredging on the Clutha, when the virgin ground in the river was not, as now, buried beneath vast deposits of tailings, good results were attained, and not a few small fortunes built up, as the result of operations with these machines. This primitive dredge, which may still be seen in operation for channel-clearing, has been largely improved in speed and capacity by the substitution of steam for hand-power, and in the form of the modern steam-shovel machine has a more extended use for gold-dredging. The principal American makers of this type of dredge are the Marion Steam Shovel Company, of Marion, Ohio, and the Bucyrus Steam Shovel Company, of Wisconsin. Two instances of the successful use of these machines are cited in the report of the Minister of Mines, in British Columbia, for 1897. In the first, Mr. W. F. Gore, the General Superintendent of the New Fraser River Gold Mining Co., in reply to an inquiry from Mr. F. Sones, Gold Commissioner, Clinton, states: "We have made dredging a known quantity, and an absolute success, not through the medium of any new invention, or combination of patents, but through the operation of a harbour dredge of the kind known as the dipper dredge, which was built to our order by the Marion Steam Shovel Company, of Marion Ohio. The dredge lifts 1½ cubic yards of material at a time, thus enabling us to work from 1,000 to 1,200 yards of material per day. For sluicing purposes, we have two direct centrifugal pumps, which raise about 7,500 gallons of water each per minute. These discharge into hoppers above the grizzlies; and the sluices and usual riffles do the rest. To my mind, it is one of the neatest and prettiest mining operations ever conducted. The scow or vessel on which the machinery is placed is 82 ft. by 38 ft. The boilers are 80 to 100 h.-p., with engines powerful enough to lift

55 tons." "In a personal interview, since receiving his report," adds Mr. Sones, "Mr. Gore informed me that the vessel and machinery were finished about the end of October last, and they hauled out into the stream for a test and to smooth bearings. Everything worked to perfection; the dipper went under the water and came up full. . . . Both Mr. Gore and Mr. Davidson, the mechanical engineer, assure me that they are perfectly satisfied that they can handle the gravels in the Fraser River. . . . The gravels last worked are from 3 ft. to 4 ft. thick, resting on a stratum of hard pan." The second instance is thus described by Mr. G. C. Tunstall, Gold Commissioner, Kamloops: "It is pleasing to note the comparative success attending the operations of the Beatty Gold Mining & Dredging Company, which are still in progress below North Bend, on Boston Bar (Fraser River). The dredge referred to* is provided with a shovel or dipper, under perfect control of the machinery, capable of being swung around, and submerged anywhere within a certain radius, and with a capacity, at each hoist, of 1½ tons of gravel, in less than one minute. The amount of material raised per diem is estimated at 800 cubic yards, and this is deposited on an inclined iron grating, or "grizzly," lying on a scow moored alongside, by which the large rocks are deposited in the river, while the smaller stones and gravel are carried into a dump-box placed underneath, and run thence into sluice-boxes furnished with different kinds of plates, riffles, and under-currents, supplied with quicksilver to save the fine gold. The shovel raises a certain amount of water, but not sufficient to run off the gravel, and a further supply for washing is provided by means of a pump. The gold is found beneath a layer of boulders, lying at or near the surface of the river bottom. Difficulty is frequently encountered in moving the scow by reason of the large rocks precipitated from the "grizzly," forming a bar in a comparatively short time, but measures will be taken to avoid this obstacle in future. The machinery is capable of working to a depth of 26 ft. As no coarse

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* Another account of this or a similar dredge, built by the same firm, is the following: The dredging and gold-saving plant rested on two scows, each drawing about 2½ ft. One of these carried a 75 h.-p. engine and boiler, 500 gallons per minute pump, the dipper and dipper arm. The other scow, anchored alongside, bore the grizzly, and sluices. The dipper was of cast iron, with a steel lip, protected by steel prongs, utilised to penetrate the cemented gravel. It had a capacity for raising 1 cubic yard of gravel each trip, and could make two trips in three minutes, dredging to a depth of 25 ft. The grizzly was composed of iron bars, set about 1 in. apart, washing water was supplied by a perforated pipe connected with the pump. The entire string of sluice boxes was 120 ft. long, the first 30 ft. to 40 ft. being 3 ft. and the rest 6 ft. wide. In the latter portion, mercury was used. The dipper discharged into the grizzly, through which the fines passed into the sluices. Large boulders and stones were washed by a man at the grizzly and then discharged overboard. This machine, which worked successfully, was employed by far the greater time, not on the cement, but on the sand and gravel at Boston Bar.

gold has been obtained, I would infer that operations did not extend as far as bed-rock, where it should be found in large quantities in the crevices and seams, under conditions which may probably render its recovery a difficult matter. The mining season is confined to the period of low water. The cost of this dredge was $18,000 (£3,600), and seven men are employed. The large boulders are hoisted on scows, and dumped at a distance down stream."

It is argued against the dipper dredge that it is ill adapted to dredging for gold, since it disturbs the gravel in the act of digging; and some of the gold, especially the fine metal, is floated away and lost. Moreover, it is unable to make a direct side cut across a river or bar, so as to systematically work and clear up the ground. Other objections are, that the material, being supplied intermittently, necessitates special arrangements for feeding the wash, in a continuous stream, to the gold saving tables; the intermittent action, moreover, throws more strain on the entire plant than the continuous work of the bucket dredge; finally, for equal capacity, the dipper dredge requires two to three times the crew of the bucket dredge, and the cost of running is nearly twice as great, the figures, according to Mr. R. H. Postlethwaite, of San Francisco, Cal., being 7 cents and upwards per cubic yard for the shovel, against from 3 to 5 cents for the bucket dredge. It is, however, well to remember that this form of dredge is, in many positions, economical of operation. This remark more especially applies to ground where the presence of numerous large boulders hampers the operation of other machines.

III.—Suction Pump Dredges.

THESE machines consist essentially of a floating structure, supplied with a powerful pump of centrifugal type, raising sand and water through a suction pipe. Characteristic types of suction dredges are the Ball and the Welman. The Welman patent pump is in many respects similar to a centrifugal pump; the runner, however, is differently constructed, the vanes or blades being merely solid cast-iron junks instead of thin, and, on the inside, greatly curved blades. The runner employed at the Waipapa' Welman dredge in New Zealand in 1889—90* was 2 ft. 3 ins. in diameter and about 8 ins. wide between the flanges, with four solid vanes greatly curved, on the back, but almost straight on the other face. On one side, the flange was solid, having slight ribs on the outside to strengthen it; while, on the other side, there was a circular opening, about 15 ins. in diameter, to allow all the water and material to pass through the runner. This runner was keyed on to a shaft, which was about 2 ins. in diameter, and had a cast-iron casing over it of about 1½ ins. in thickness, and revolved at the rate of 430 revolutions per minute. This forms the Welman pump.

The hull or punt of this dredge was 50 ft. long and 15 ft. wide, and, on each side of this punt, there were three pontoons, the four end ones being 4 ft. and the centre one 6 ft. wide. These pontoons were placed alongside the main punt on each side, end on end, and were held together by longitudinal beams lengthwise, and to the main punt by heavy cross-beams, which crossed the deck, extending from 7 ft. to 8 ft. on each side. This admitted of these beams being bolted to the longitudinal beams which held the pontoons together so as to form a platform to erect staging for the washing tables. There were also two pontoons at the stem of the dredge, fastened by beams to the main punt, to carry the staging for the end of the washing tables and tail boxes, which delivered all the water and waste material on to the ocean beach, the tailings being prevented from banking up, to any great extent, by the waves.

The pump was placed on the main punt, and from it there was a horizontal pipe with an elbow to join on to the casing, and fit on a projecting flange on the runner. This horizontal pipe, after passing to the front end of the punt, was fitted with a universal joint, so that the pipe outside the punt could be lowered, raised, or moved from one side to the other. On the end of the outside pipe, there was an elbow turning downwards, and having a bell-mouthed sleeve over the end. The suction and delivery pipes were 12 ins. in diameter; but in order to prevent stones jamming in the pipe, there was a ring fixed inside the bottom end of the suction pipe, thus reducing its diameter to 10 ins.; therefore, any stone which came through this ring could easily pass through the pipe, but there was still a danger of its jamming in the runner. The dredging pipe was lifted and lowered by a steam winch, the derrick being placed directly at the front end of the punt and dredging round on a pivot, so that the pipe could be made to describe an arc of about 160 degs.; by this means a cut or paddock could be excavated from about 45 ft. to 50 ft. wide. After taking up one cut, the dredge was shifted back again and another cut begun. There was a vacuum-gauge attached to a pipe, leading from the top of the universal joint of the dredging pipe, and this gauge showed the man that guided the dredging pipe how it was working. If everything was going on smoothly, the gauge registered 5 lbs. pressure per square inch, but if a stone got into the bottom end of the pipe, it immediately rose considerably above this, or, if a stone jammed near the runner, the gauge fell below the 5 lbs. By this means the man conducting the dredging operations could at once tell what was the matter, and remedy it accordingly. The dredge was designed to lift 80 tons per hour, but it did not lift more than about 35 tons. The height of lift was 15 ft. above water level.

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* "Reports on the Mining Industry of New Zealand," 1890, p. 87.

As regards the value of suction dredges, it may be said that, for gold-dredging purposes in rivers, they have had their trial, and mostly failed. For sand or slurry, the centrifugal pump has proved its value; but, for river gold dredging, it has certain practical defects. In the first place, the large volume of water* it raises tends to flood the tables and sluices, and prevent the gold settling. Sluices also, of the breadth needed for the large flow of water, are expensive to make, difficult to maintain in equilibrium, and troublesome to clean up. In the third place, the suction force being intense near the pipe-mouth, and decreasing rapidly a short distance away, is apt to draw the sand and gravel away, leaving the heavier gold behind. A centrifugal pump, therefore, is of little use to raise coarse, heavy gold, especially on a hard, uneven bottom. It obviously cannot disintegrate and raise hard ground. An attempt has been made to remedy this defect by fitting the suction pipe with a chisel or plough blade, adapted to loosen the ground. But cutters of this description are ineffective, and lead to further trouble, since the gravel is disturbed by the cutting and the gold separated from it.* Inability to deal with the tightly-cemented ground caused the failure of the Welman dredge on the Manuherikia River. Again, a suction dredge is subject to frequent interruptions owing to the grating in front or the pipe itself becoming choked with stones, weeds, &c. Mr. D. Wilson, of New Zealand, has devised a sectional grating box for protection against choking by weeds, and the trial is said to have been satisfactory. Lastly, suction pumps cannot work on viscous clayey ground, nor economically raise coarse material, as a runner construction capable of passing large stones involves great loss of efficiency. Possibly this difficulty may be overcome, but at present the suction dredge can deal economically only with fine material, as in the case of the Welman machine at Waipapa, where the great bulk of the stuff, or about 95 per cent., was sand and fine shingle. At Saltwater Creek, Paeroa, New Zealand, in 1889—90, Messrs. Brown & Co., of Wellington, erected a dredge with a cataract pump for lifting sand and shingle; but, though this pump was highly spoken of as an efficient dredge by people in America, it proved suitable for raising only material up to about 3 ins. in diameter, and was therefore quite unfitted for dredging the bed of Saltwater Creek. This inability to deal with coarse material largely restricts the utility of the machine. Tempted by its success for harbour and river channel work, and its apparent suitability for operating over rough ground, where obstacles abound, several companies have tried the suction dredge on the rivers of British Columbia, the Upper Fraser, the Quesnelle, &c.; but there, as at almost every other place, it proved to be utterly useless. Among the more recent witnesses to this fact may be cited the following: Mr. J. Bowron, Gold Commission, Cariboo District, writes†: "I feel safe in saying that in this district the suction dredges have proved a failure." Mr. G. C. Tunstall, Gold Commissioner, Yale Mining Division, states‡: "The Fraser River Consolidated Gold Company has operated on the bars of the Fraser River, between Ruby Creek and Hope, with a powerful dredge on the suction pump principle, which, so far, has not been successful. Alterations will shortly be made by the substitution of buckets for the present system." Mr. G. Wilson, reporting to the Minister of Mines, New Zealand,§

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* Observations, made on the suction dredges raising fine gravel in Start Bay for the Plymouth Dockyard Extension Works, showed that the gravel varied, according to circumstances, from 5 per cent. to 20 per cent. of the total volume elevated.

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* The "Transactions of the American Society of Civil Engineers," 1898, p. 223 *seq.*, contain a paper describing a number of dredge scrapers, &c., tried or proposed, for dealing with hard ground, such as rotating screw blade excavators, dredge keel scrapers, conical screw scrapers, horizontal revolving shafts fitted with serrated disc-cutters, vertical ditto, submarine ploughs, wedgeprow dredges, submarine harrows with water jets at every tooth, revolving spiral cutter, which, shaped like a spiral conveyor, is lowered to the requisite depth and revolved by the flow of the current; powerful water jets also have been tried.

† "Report of Minister of Mines, British Columbia," 1898, p. 981.

‡ "Report of Minister of Mines, British Columbia," 1899, p. 743.

§ "Reports Relating to Minerals and Mining, New Zealand," 1899, p. 140.

mentions that: "Dredging for gold by means of suction dredges has also been tried to a considerable extent in New Zealand, but has proved a failure in every case. There have been sixteen suction dredges put upon different claims, including two fine plants sent out by Messrs. J. H. Gwynne, of London, and in no case have they proved profitable investments. There is a considerable amount of wear and tear on the pumps, and the power required to drive them is so great that the fuel account is out of all proportion to the amount of work done. In hard wash, where the best gold is generally to be found, the suction pump appears to be almost useless, for it will not lift the wash without some kind of a cutter to disturb it, and, so far, no cutter has yet been made in New Zealand that will stand in the wash or gravel." Again, in the official report for 1899—1900, Mr. Warden Poynton states: "The suction dredge erected on one of the Waiau claims is now being altered to a bucket dredge." And, in the "New Zealand Mines Record," November 16, 1904, p. 142, it is stated: "Campbell's Creek, near Castlemaine, was at one time the scene of operations of a suction-pump dredge, which did not pay. Now a Melbourne company has a bucket dredge working the same ground, and, it is understood, with fair results." From reports issued by the Mines Department of Canada, it seems that suction dredges have also been tried there, but from the published returns in their reports they do not seem to be very successful. A writer in the "New Zealand Mines Record,"* discussing the working of the sea beaches between Hokitika and Greymouth, on the west coast of New Zealand, observes: "Some twelve years ago suction dredges were tried, but were not a success." As the rivers of British Columbia and the sea beaches of New Zealand offer the conditions presumed to be most favourable to these dredges, it may be safely assumed that, at present, they are unsuitable gold-savers for river or beach work.

On the other hand, for operating on banks and river flats, by what is known as land-dredging, the suction or centrifugal pump is in common use. For this, however, there are special reasons, discussed elsewhere by the writer.†

Although the suction-dredge is generally condemned, it is possible to imagine conditions under which a suction-pump might form a useful addition to the grab or to the bucket dredge. In December 1904, Messrs. W. Simons & Co., Limited, Renfrew, Scotland, launched such a combination dredge, the Murihiku. Besides being fitted with a special set of buckets for dredging rocky ground, the vessel was fitted with a sand suction-pump. The buckets, as well as the suction-pipes were made to dredge to a depth of 40 ft. The hopper was arranged in such a manner that the dredgings could be relifted from the hopper and discharged over the side by a special patent arrangement of the builders, and delivered ashore through a long line of floating pipe for land reclamation, or into barges moored at the side of the dredger. Ordinary hinged doors were also fitted to the bottom of the hopper, so that the material could be deposited at sea when required. The machinery consisted of two sets of triple expansion engines and two cylindrical boilers of 160 lbs. working pressure. All the latest appliances, including water heater, evaporator, filter, and electric light installation were fitted on board. The Murihiku was constructed to the order of the Agent-General for New Zealand, under the direction of Messrs. Carruthers & Elliot, Consulting Engineers, London, and Mr. R. M. E. Ashworth, Resident Inspector.*

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* July 16, 1900.

† "Hydraulic Mining," Part III., 2nd edition.

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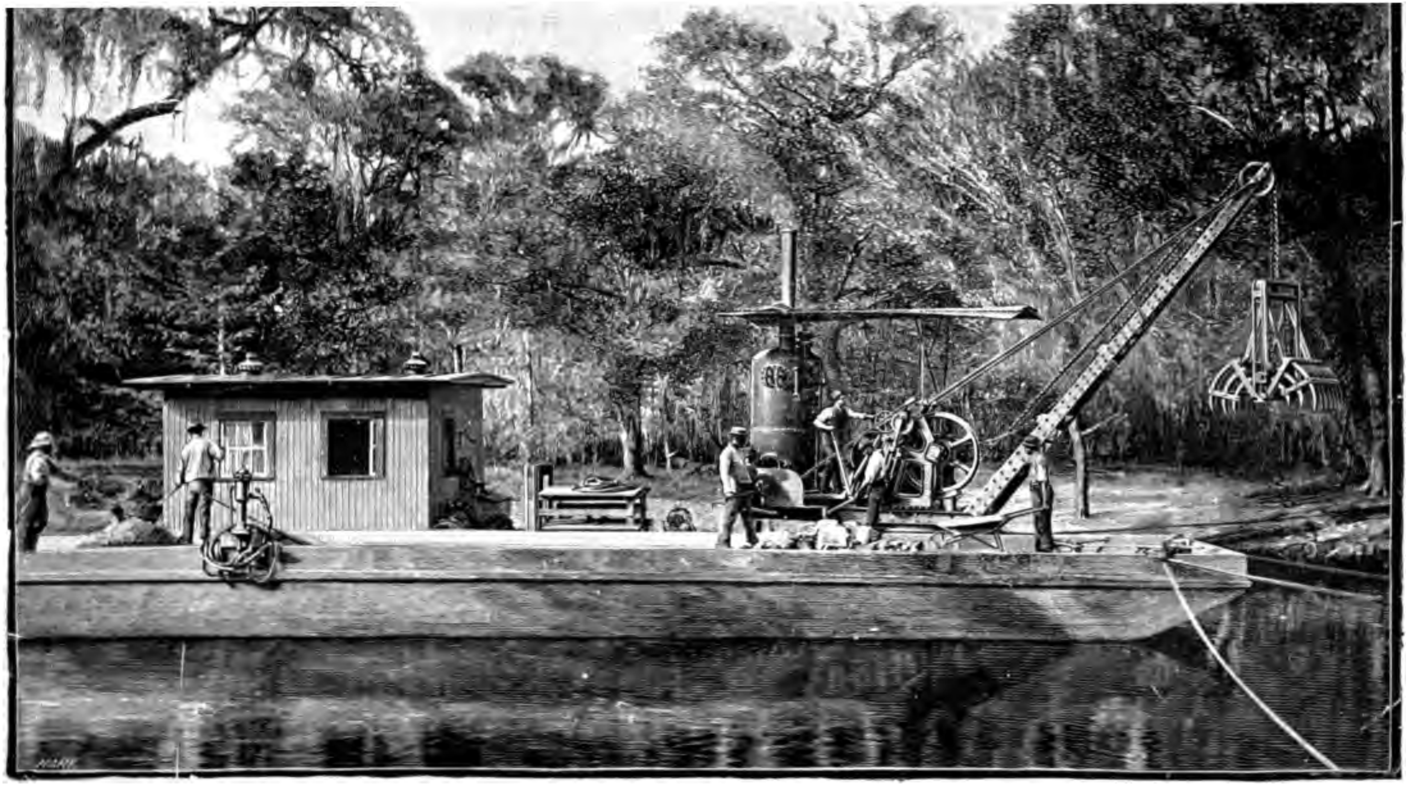
* "The Mining Journal," December 31, 1904, p. 676.



One of two "Kingston" Grab Dredges, B Size, lifting capacity 4 tons, supplied by Messrs. Rose, Downs & Thompson, Limited, of Hull and London. The dredge, mounted on wood pontoon, is fitted with free-falling grab, under control of the engine driver, and capable of being opened or closed, when on the ground, and of discharging or lowering at any point.

pipe, were made to dredge to a depth of 40 ft. The hopper was arranged in such a manner that the dredgings could be relifted from the hopper and discharged over the side by a special patent arrangement of the builders, and delivered ashore through a long line of floating pipe for land reclamation, or into barges moored at the side of the dredger. Ordinary hinged doors were also fitted to the vessel's own hopper, so that the material could be deposited at sea when required. The machinery consisted of two sets of triple expansion engines and two cylindrical boilers of 160 lbs. working pressure. All the latest appliances, including water heater, evaporator, filter, and electric light installation were fitted on board. The Murihiku was constructed to the order of the Agent-General for New Zealand, under the direction of Messrs. Carruthers & Elliot, Consulting Engineers, London, and Mr. R. M. E. Ashworth, Resident Inspector.*

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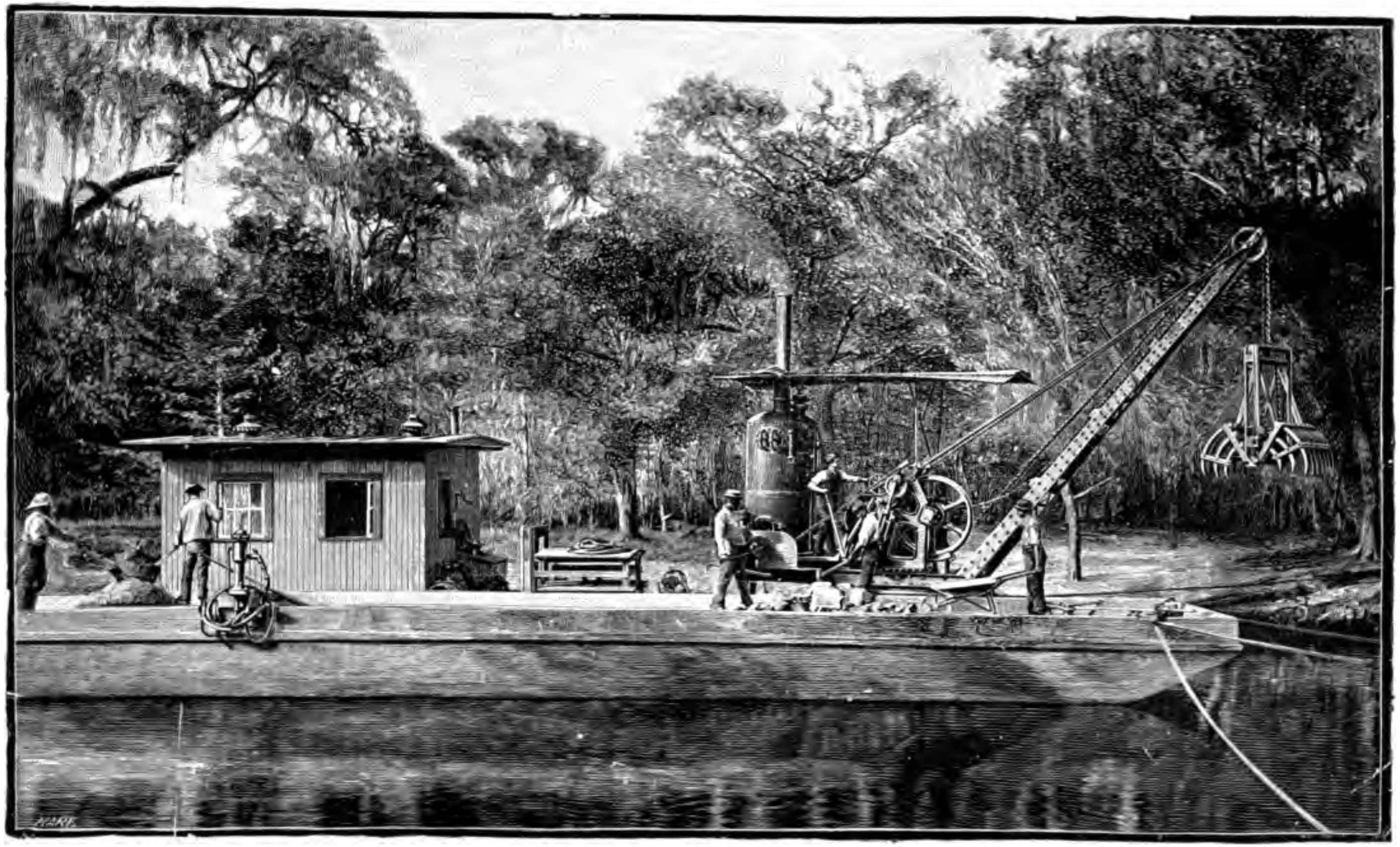
* "The Mining Journal," December 31, 1904, p. 676.



One of two "Kingston" Grab Dredges, B Size, lifting capacity 4 tons, supplied by Messrs. Rose, Downs & Thompson, Limited, of Hull and London. The dredge, mounted on wood pontoon, is fitted with free-falling grab, under control of the engine driver, and capable of being opened or closed, when on the ground, and of discharging or lowering at any point.

IV.—The Grab, or Clam-Shell Dredge.

The grab, or "clam-shell" type of dredger, consists of a self-filling and discharging scoop or bucket, with the necessary engine power for working this from a crane. Well-known makers of this form of dredge are Messrs. Rose, Downs, & Thompson, Limited (*see* illustration), and Messrs. Priestman Bros. Both firms recommend, for this purpose, the double-chain grab. A one-ton capacity Kingston dredge, with 7-in. diameter cylinder, 10½-in. stroke engine, 50 lbs. working pressure, and surplus boiler power to drive a centrifugal pump, trommel, and winches would cost about £600. The weight of such a grab, with engine and boiler, would be about 17 tons; platform dimensions, 5 ft. by 6 ft. The vertical lift from deck board, for stability, should not be over 20 ft., or, deducting the length of the grab, say, 14 ft. effective. As the working of the grab causes considerable oscillation of the barge, it is well to place the gold-saving tables, sluices, &c., on a separate barge. It is, therefore, probable that a complete dredging plant, capable of dealing with 40—50 tons per hour at a moderate depth would cost about £2,250, pontoons included, but built locally from cheap timber. Another form of grab is that of Hone, manufactured by the Thames Ironworks, Limited, London. It is of the single-chain type; it does not require to be dropped with force, but when lowered gently will sink itself as soon as power is put on, and in ordinary soft material it fills up to its full capacity. It is also provided with a hydraulic cylinder break, by which the discharge is made gradual. The cost is rather high, a grab alone, of 1½ cubic yards capacity, costing £120. For dredging in ground where there are obstructions the double-chain grab has the advantage that the grip of the grab on any obstruction can be immediately released, whereas with the Hone grab it might be necessary to send down a diver for that purpose.

In certain localities, the grab dredge has advantages over the bucket or ladder type. Amongst these are the following: It goes into small compass, can be easily moved about, can be worked in confined places where a ladder dredger would be useless; the wear and tear is small; it will work to varying depths without requiring adjustment; one man can work the crane, and, when not required for dredging, the machines, by detaching the grab, can be used as an ordinary lifting crane, which is often a great convenience. "Grabs" with a capacity of from 3 cwt. to 40 cwt., or more, are supplied by the makers, and the type of grab used depends upon the nature of the material to be lifted; but in sending abroad it is very usual to supply one of each of the types usually illustrated in trade catalogues.

Notwithstanding the advantages mentioned, the grab dredge is obviously not the most efficient machine for gold-dredging, for several reasons, one being that the grab cannot be made watertight, consequently some of the gold is likely to be carried away by the out-draining water, while the grab is being elevated. Again, it is not easy, even with the best arrangement of hopper, to wash and properly treat the material which is dumped into it intermittently in large quantities. Further, grab dredges are unsteady in work, and, therefore, unsuited for the proper action of sluices and gold-saving tables. Finally, the proper vertical fall of the grab is interfered with by a rapid current, say of from five to six knots and upwards per hour. Nevertheless, this type of machine has often done good work. At Greymouth, New Zealand, the only dredge that, up to 1890, had been made to pay for working was a combination of a pump and a Priestman grab. The former raised the sand and small shingle, and the latter the coarse gravel and boulders. Mr. Franklin White, writing on the use of these dredges for saving gold, says:—

"The Priestman dredger which, on my recommendation, was supplied to the French (Nechi) Gold Mining Company for dredging for gold in South America, worked to my entire satisfaction, and I know of no other system of dredge so adapted to the general requirements of such work.

"The bed-rock in the River Nechi was reached at a depth of 15 ft. to 16 ft. from the present bed of the river; the bucket excavated its way very well through sand, shingle, pipeclay, &c. It appears that a very small proportion of the gold contained in the deposit escapes the grab. Many pieces of tree trunks are found bedded in the gravel beds, and these impediments, so troublesome to a ladder dredger, are managed easily by these machines. The fact that grab dredgers are able to penetrate the beds to any ordinary depth, without having to be stopped for adjustment, is a point which certainly merits attention. I believe this machine has only to become more widely known amongst miners to be very largely used, as there are many rivers which are too big to be easily diverted from their channels, and yet contain valuable deposits easily to be obtained by a proper class of dredging machine."

The quantity of deposit raised depends very much, of course, on the depth from which it is to be lifted, and on the nature of the material; but, supposing the grab in use to hold 20 cwts. of deposit and to be working in 20 ft. of water, the output in ordinary material should be about 40 tons per hour, estimating the dredger to make

50 lifts per hour, or, say, 500 tons per day of 10 working hours. The consumption of coal on this sized machine would be about 90 lbs. per hour, or, say, 2 lbs. of coal per ton of deposit lifted.

Where coal is not easily available, special fire-boxes are supplied to burn wood, if this is obtainable. When working in very stiff clay or hard gravel, the output would probably not exceed two-thirds of the above, or in some cases possibly not more than one-half, though the coal consumption would be practically the same (90 lbs. per hour).

The above remarks specially refer to a grab crane fixed on a barge, but the reader will readily understand that these machines are equally of service on shore, the grabs being worked from locomotive travelling cranes, instead of from fixed cranes; all cranes, however, which are required for constantly working grabs, should be made specially strong to stand the more or less constant strain that is put upon them.

Messrs. Rose, Downs, & Thompson, Limited, of Hull and London, are the sole manufacturers and patentees of the Kingston Double-chain Grab Dredge, of which an illustration is given.

V.—The Bucket Dredge.

THE bucket dredge may be described as a continuous dipper dredge, the material being raised by a revolving chain of dippers or buckets, which scoop or dig into the deposit. The principle and system of raising material in these machines are almost identical with those of harbour dredges. The favourite type of bucket dredge is that known as the endless chain centre bucket dredge.*

An endless chain of buckets is carried on rollers resting on a steel ladder. The upper end of this ladder is hinged on a gantry frame about 20 ft. above the deck of the dredge. The lower end of the ladder is suspended by cables, which pass over sheaves to a drum on a winch, so that the ladder may be raised or lowered to feed the buckets. The buckets pass over tumblers at the upper and lower ends of the ladder. The power to drive the bucket line is applied at the upper tumbler through gears. The material as excavated by the buckets is dumped into a hopper, and from this hopper is fed to revolving or shaking screens. Water under pressure is forced from spray pipes over the screens on to the travelling gravel. The gold-bearing material passes through the screens into a distributor, which feeds this material and water to tables provided with riffles. These tables in turn discharge into side or tail sluices, which deposit the fine tailings well behind the dredge. The coarse tailings, after being washed on the screens, pass from the screens to a conveyor, which carries these tailings 30 to 50 ft. behind the dredge and stacks them 20 to 30 ft. high.

The usual construction of such machines may be illustrated by the description of a dredge built by the Risdon Ironworks, San Francisco, to work on the Yuba River. The dredge consists of two large pontoons, each 86 ft. long by 9 ft. beam. These are connected at the stern by a small pontoon 17 ft. long and 5 ft. wide, the bow being connected by a heavy overhung beam. This practically makes one boat, 96 ft. long, 23 ft. wide, with a well-hole 5 ft. wide running through the centre for some 75 ft. As the name implies, the chain of buckets and the ladder round which it revolves works in this centre

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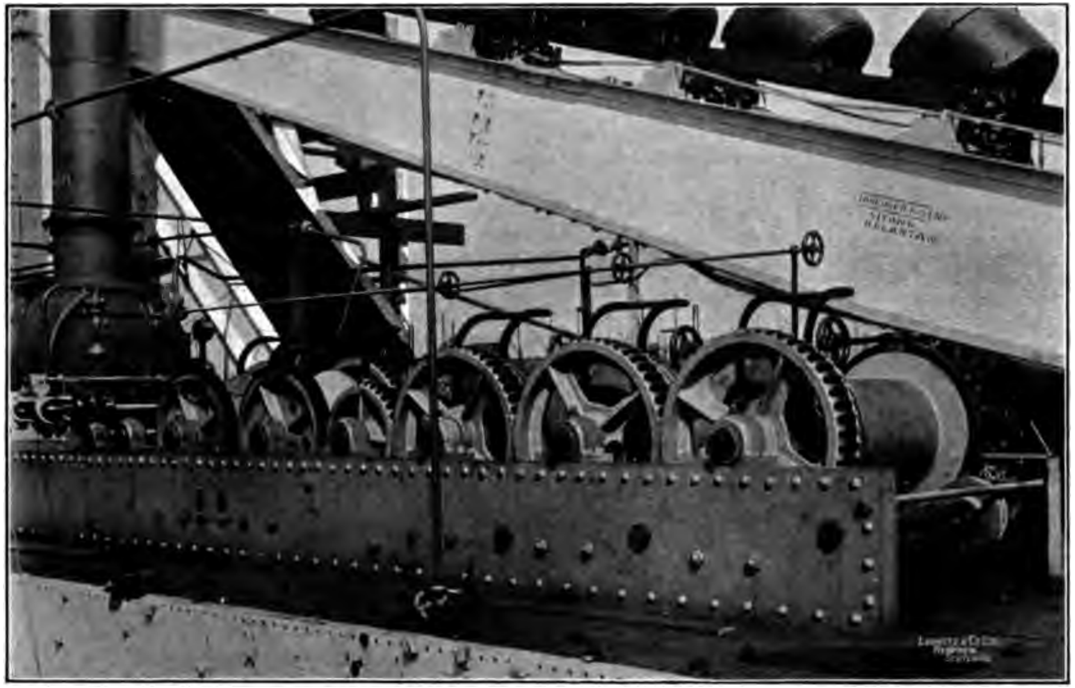
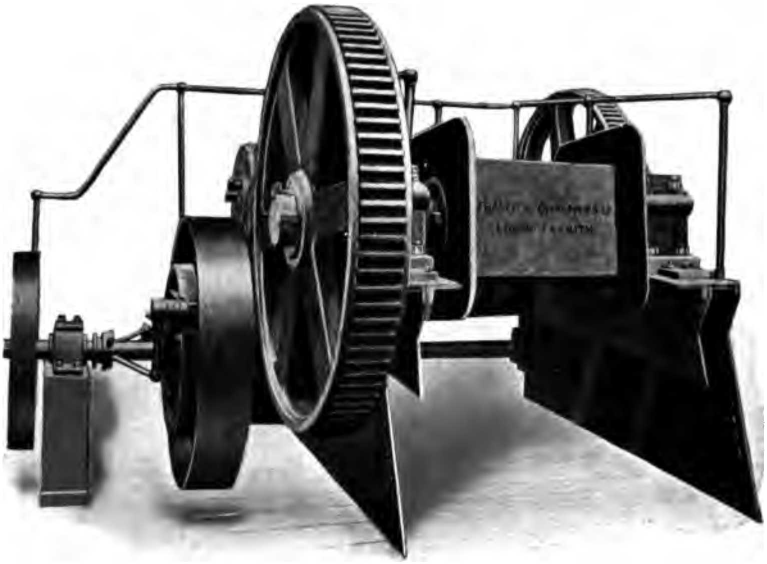
* Bucket dredges have been built with one pontoon and two bucket ladders, one on either side. This was the plan of the Dunedin Company's dredge in 1882. But the two ladders were not a success, for the alternate action of dredging into the wash, first on one side and then on the other, together with the two sets of buckets never filling equally, occasionally rolled the decks under water, rendering the pontoon quite unsuitable for gold-saving appliances.

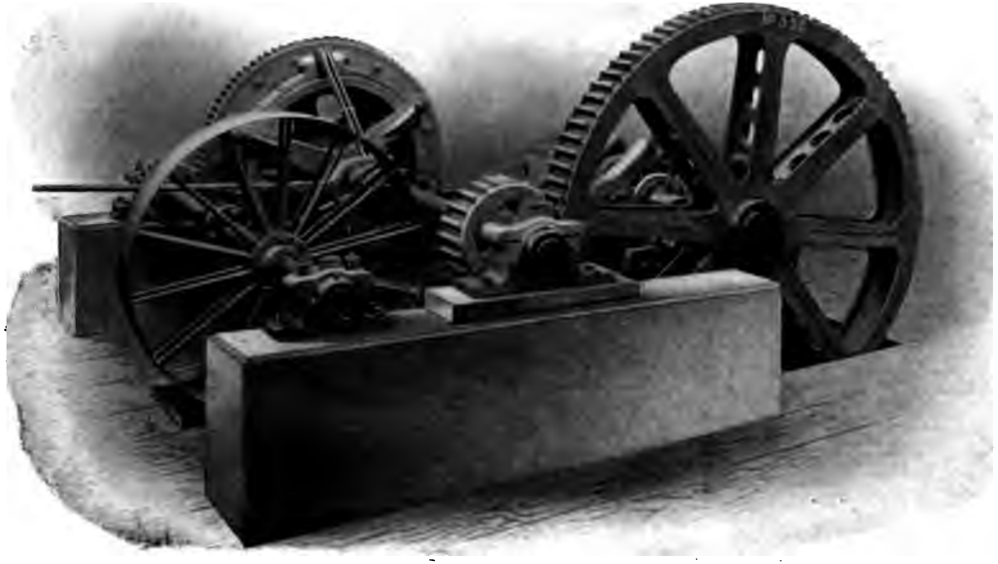


Detail Deck View of Dredger.—Built by Messrs. LOBNITZ & COMPANY, LIMITED, Renfrew, Scotland. Showing Bucket Ladder, Buckets, and Winches, &c.



A Top or Upper Tumbler, as built by Messrs. FRASER & CHALMERS, LIMITED.
The main power receiving pulley drives the counter-shaft through a friction pulley.

14—C



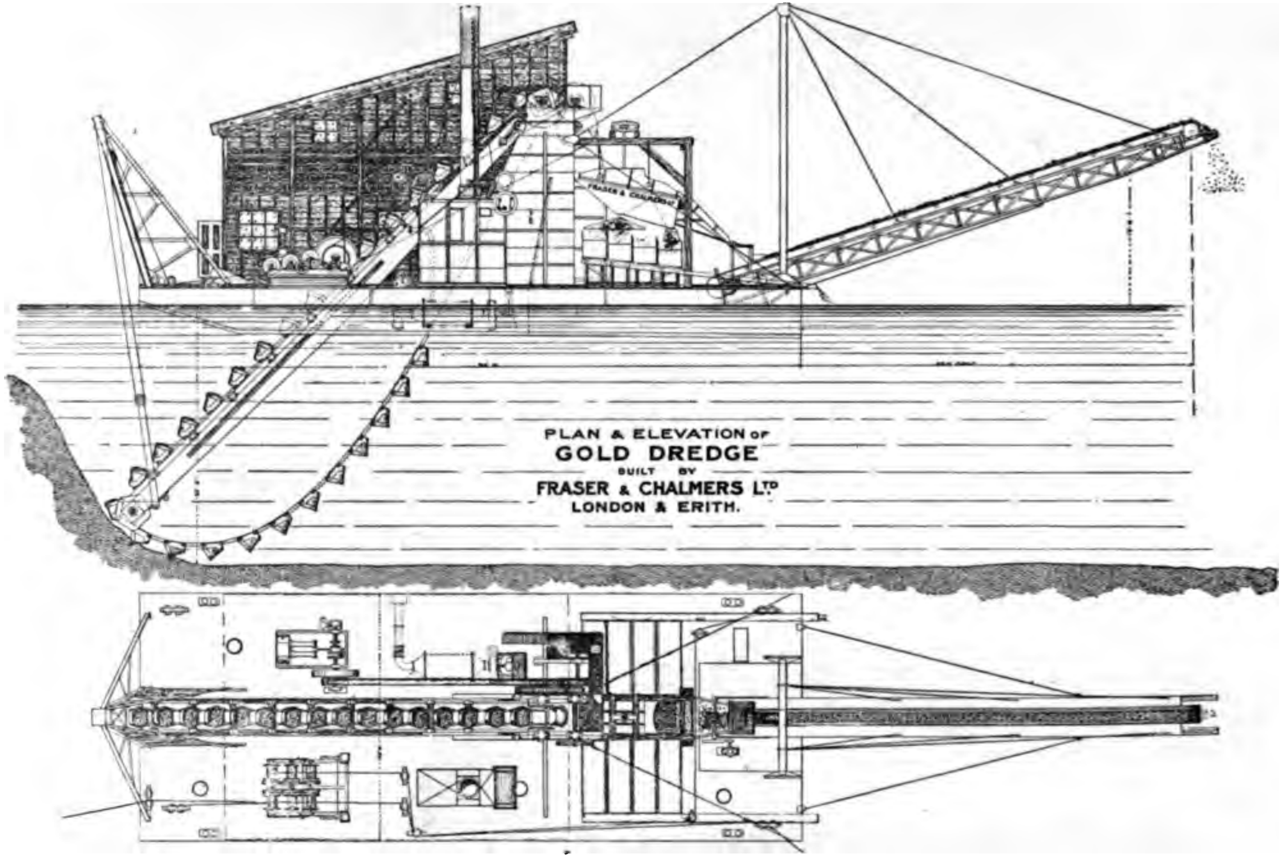
Top Gear (Sectionalized Type).—Designed and made by Messrs. LOBNITZ & COMPANY, LIMITED. 14—D

well. The ladder, varying according to the depth of the river, and in this case 67 ft. long, is built up as a heavy lattice girder, and hung at the stern end by a bar fixed across a heavy wooden frame. The lower end of the ladder carries a five-side tumbler, and is suspended by blocks and tackle to a cross-beam. By means of wire rope and blocks, the winch can raise or lower the bottom as required. The top tumbler is carried by the timber framing some 3 ft. above the top end of the ladder. The continuous bucket chain comes up the top side of the ladder on rollers round the top tumbler, and back in a catenary curve to the lower tumbler. The top tumbler is driven by belt or rope transmission and heavy gearing from the engine. In a later dredge, on the gearing between the engine and the buckets there is a friction clutch, which not only allows the buckets to stop when they come in contact with anything too firm or heavy to lift, and start again when the pressure is relieved, but enables a mere movement of a lever to instantly stop the buckets without stopping the engine or interfering with any other part of the machinery. The winchman has his lever close at hand, and can control his buckets independently and without communicating with the engine-driver. A vertical compound condensing engine of 35 indicated horse-power is used; this also drives the centrifugal pump, throwing 3,000 gallons per minute for washing purposes. This water thoroughly washes the material, which is delivered from the buckets into a revolving screen or grizzly, from which the finer dirt, which is here usually not more than 10 per cent. of the amount raised, together with its gold, falls into a distributing box, and thence on to gold-saving tables 11 ft. wide, discharging into a flume.

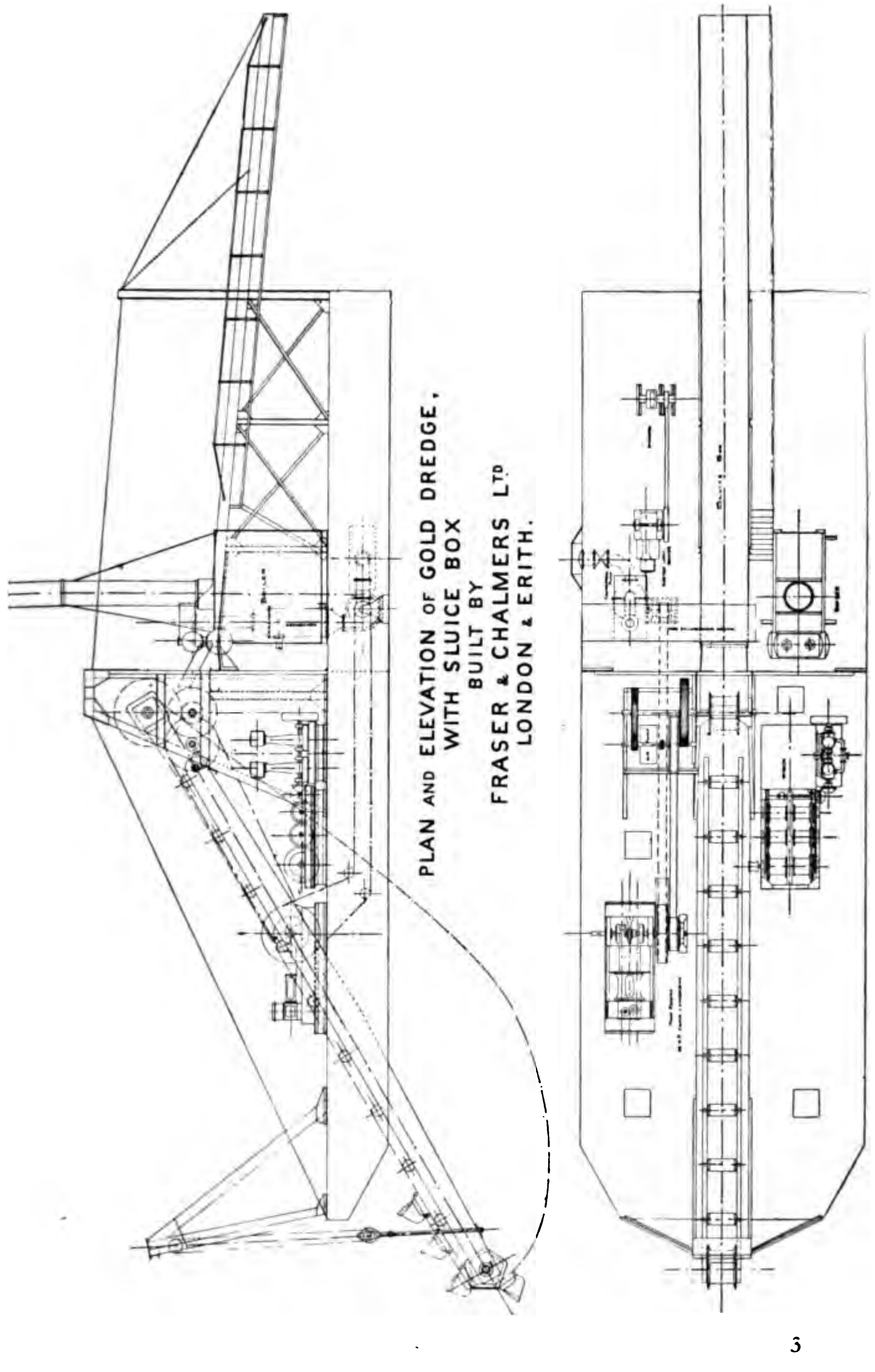
A more recent dredge, designed by Messrs. Cutten Bros., of Dunedin, in 1903, for the Feddersen Gold Dredging Company, Limited, Three Channel Flat, Butler River, has a length of 86 ft., beam 29 ft., depth 7 ft. The ladder is 56 ft. long, and, when at an angle of 45°, is capable of dredging to a depth of 30 ft. The buckets have a capacity of 5 cubic feet each. The elevator is rope driven, the power being applied to the top tumbler, and the tailings can be stacked to a height of 30 ft. Steam is generated in a multitubular boiler of 30 n.-h.-p. The main engines are of the compound type, rated at 16 n.-h.-p., and built by Marshall, Sons, & Co., Limited. The winches are worked by a pair of coupled vertical engines. A revolving screen is used, and the tables are covered with expanded metal above the matting. The Davis patent grapnel has been adopted on this dredge.

The following plans and elevations illustrate gold dredges, built and fitted by Messrs. Fraser & Chalmers, Limited.

The advantages of bucket chain dredges as a class are: Their suitability for handling either coarse or fine material, and for dealing



PLAN & ELEVATION OF
GOLD DREDGE
BUILT BY
FRASER & CHALMERS L^TD
LONDON & ERITH.



PLAN AND ELEVATION OF GOLD DREDGE,
WITH SLUICE BOX
BUILT BY
FRASER & CHALMERS LTD
LONDON & ERITH.

with the varying conditions on the river-bed or flat on which they may be operating; their power of dredging to 60 ft. and over in depth, of working into banks considerably above water level, and of stacking the tailings behind to a height of 30 to 40 ft.; their efficiency as an excavating apparatus, clearing the bottom, and handling the material with little agitation, while they slowly and continuously feed a tolerably regular quantity of material to the gold-saving appliances, thus fulfilling a condition essential to good extraction. Finally, they are relatively economical in their consumption of power. The chief disadvantage is that they are not very successful in lifting gold from a hard and rough bed-rock.

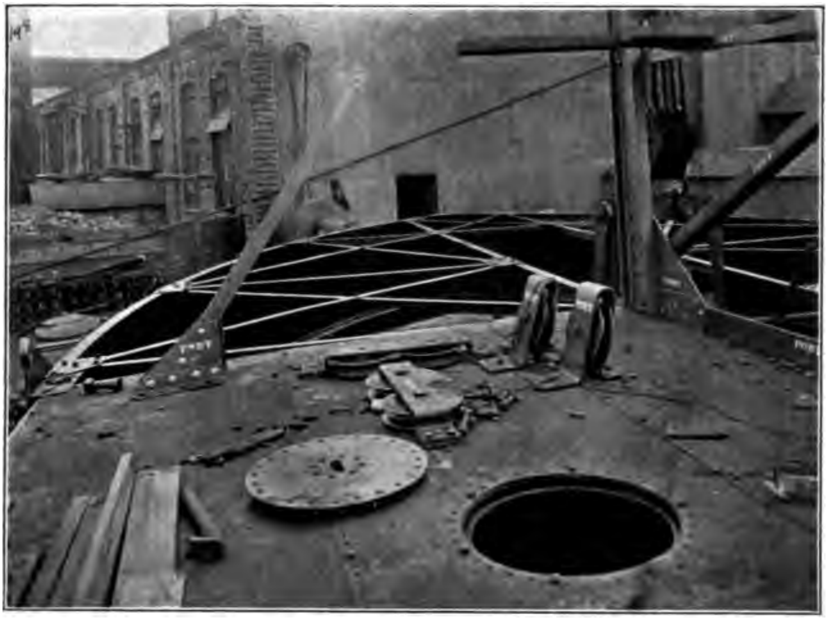
CLASSIFICATION OF BUCKET DREDGES.

1. According to the Nature of the Work.

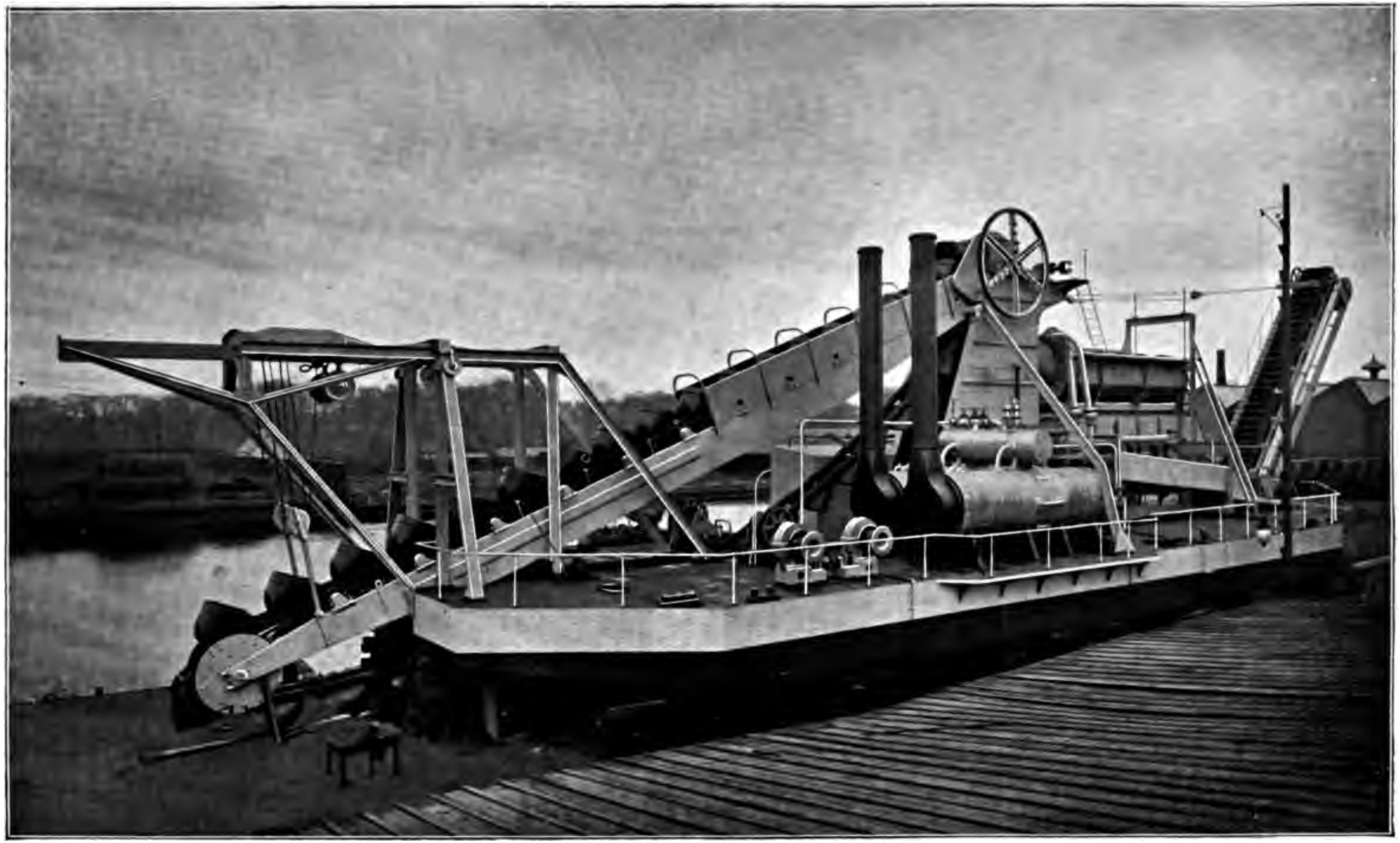
Under this heading bucket dredges may be classed as: River dredges; paddock dredges.

The river dredge is designed to work with some depth of water underneath it, and is not called upon to cut its own flotation. It is, therefore, not provided with a projecting ladder to eat into banks, nor with sharpened bows to work into corners; but, as a rule, is built square across the bows, especially if working in a current such as runs in the Molyneux in New Zealand, for the practice there has proved that a square-nosed dredge remains steadier in the current, and does not "yaw" about so much as a sharp-nosed one. Of course, square bows offer much greater resistance to the current and require heavy lines to hold them, but as a dredge is not built for speed, resistance is not taken into consideration to any extent beyond the usual practice of making the floor of the pontoon take an upward curve at the bow.

A paddock dredge should draw as little water as possible, and the draught should not exceed 5 ft., even in large dredges; a fair average draught is about 3½ ft. with twenty-four hours' fuel on board and the dredge gear. The bows of a paddock dredge should be well rounded to permit of being easily manipulated in a corner, and should also be more heavily planked and framed than the other pontoons, so as not to be damaged by striking a face, as the dredge surges at her work. Very often the bows are sheathed with steel plates as a protection against blows and chafing. The bottom of the hull at the forward end should be sprung or bevelled upwards for clearance and handiness in working, and the bottom from the bows aft to the position of the ladder at the "maximum dredging depth" should have the thickness of planking considerably increased to obviate accidents through logs being caught in the buckets, and by their being



Method of Strengthening Hull by the addition of a False Bow.
Fitted by Messrs. FRASER & CHALMERS, LIMITED, to one of their dredges. 18—A



Paddock Bucket Dredger with Gold-Washing Apparatus.—Built by the Shipbuilding and Engineering Company, WERF CONRAD, LIMITED, Haarlem, Holland.

dragged upwards through the bottom. This type of accident is by no means infrequent.*

The principal dimensions of the "Werf Conrad" Paddock Bucket Dredger, as illustrated, are:—

Length, 28.80 m.
Breadth moulded, 9 m.
Depth, 1.35 m.
Draught, ± 0.75 m.
Dredging depth, 0 to 7 m.
Output per hour—
In hard material, 50 m^3.
In light material, 70 m^3.
Total engine power, 80 i.h.p.
Heating surface of boilers, 60 sq. m.
Total surface of tables, ± 50 sq. m.

The following is a description of the Earnscleugh No. 3 Paddock Dredge: —

The dredge is the ordinary bucket type, electrically driven, with dimensions as follows—

Length of hull, 130 ft.
Width of hull, aft, 34 ft.
Depth of hull, aft, 7 ft. 6 ins.
Width of hull, forward, 26 ft.
Depth of hull, forward, 5 ft. 6 ins.
Length of main ladder, 90 ft. between centres.
Capacity of buckets, 7 cubic feet.
Speed of buckets, 9½ per min.
Lift of dirt from deck to centre top tumbler, 17 ft. 6 ins.
Lift of water, 17 ft. 6 ins.
Diameter of centrifugal pump, 12 ins.
Diameter of screen, 7 ft. (friction driven).
Length of screen, 30 ft. (friction driven).
Length of tables, 24 ft.
Width of tables, 16 ft., giving a spread of 384 sq. ft.
Diameter of silt-wheel, 12 ft., 4 revolutions per minute.
Width of silt-buckets, 10 ins.
Depth of silt-buckets, 6 ins.
Length of elevator-ladder, 128 ft. centres (bottom drive).

Winches—worm and friction-wheel type—driven by 20 h.-p. motor. Buckets, pump, screen, silt-wheel, and elevator all driven off a shaft extending the full width of the dredge, with the necessary belts, pulleys, and gear-wheels, by a 100 b.h.p. motor. The dredge is floating about 20 ft. from the surface, and takes three to four heads of water running into the paddock to keep it at that level. When first started, the dredge stood 50 ft. above the level of the Molyneux River, a quarter of a mile distant. The dredge was built in a hollow on a terrace adjoining the Earnscleugh Nos. 1 and 2 Claims, and, when ready, was floated by means of a water-race being turned into the dam.*

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* "Gold Dredges: Their Construction and Manipulation," D. K. Blair. The "Canadian Mining Review, 1902," p. 275 *seq.*

The necessity for paddock dredges grew out of this condition; the high bars and gulches were worked by ground sluicing and hydraulicing because there was enough grade to carry the water and tailings down hill, away from the work. But down below these high bars and gulches were larger valleys containing gold-bearing gravel beds, in which there was not enough grade to carry off the tailings. These latter gravel beds are very extensive, and generally richer in gold. In order to sluice this material, it was necessary to dig it, and then lift it to a height which would give the requisite grade for properly working the material. The dredge does this. It is a self-contained machine which scoops out and lifts the material, screens out the large boulders and coarse rocks, and then sluices the material with the water which it raises with its own pumps.

The curious feature of this form of gold dredging is that the dredge floats in an artificially made pond, and then carries the pond along with it. After the prospector has located the gold-bearing gravel deposit, and the experts have satisfied themselves that the gold is there, the timber and machinery for building and equipping the dredge are assembled. Sometimes the point of attack is within easy reach of a railroad. Sometimes it is a hundred or more miles from the rails in some wild canyon. In either case, there must be water which can be pumped or brought to the place through pipes or a ditch. With wheeled scrapers and other forms of dry excavators a shallow pit is dug, and on the dry bottom of this waterless pit the pontoon or hull of the dredge is constructed, and while the boat-builder is at work other men are digging the ditch or laying the pipe to bring the water to the dredge. When the water arrives the pit is filled, and then the dredge is afloat in a pond some 150 to 200 ft. wide by about 200 ft. long, where no pond was before. This pond is a movable pond, for when the dredge is working it excavates in front and fills in behind, so that in time the pond is a considerable distance from its original site.

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* "New Zealand Mines Record," April 16, 1904.

2. *According to the Motive Power.*

According to the motive power employed, bucket dredges are termed: (*a*) Current-wheelers; (*b*) Steam; (*c*) Electric; (*d*) Turbine; (*e*) Pelton-wheel Dredges.

(*a*) *Current-wheel Dredges.*—The mechanism on these dredges is driven by an under-shot water-wheel, placed at one or at both sides of the scow and rotated by the current. Such dredges work with most safety and regularity in about a 3-knot current.

An instance of a machine of this kind is the Mannherikia dredge,* working, in 1894, on the Clutha. The boat was 60 ft. long, with 22 ft. beam. The estimated output was 30 tons of wash-dirt per hour, and the labour one man per shift. The sluicing water was raised in small buckets attached to the rim of the current wheels. In the part of the river operated on, the stream was very rapid from side to side, and enabled the dredge to do all that a steam machine could and at much lower cost.

L. Gard's No. 2 dredge,† on the same river, was 78 ft. long, 20 ft. beam, and 5 ft. draught. It dredged to 27 ft., lifted from 35 to 40 tons per hour, and employed generally one man per shift. The sluicing water was raised by buckets, as above. The average cost of working was £14 per week.

In the Victoria dredge, Alexandra,‡ the current wheel was 22 ft. in diameter, and was estimated to develop 15 h.-p. on a 5 to 6-mile per hour current. There were 14 floats on each wheel, which revolved seven times per minute. The buckets were calculated to hold 2 cubic ft., and to discharge at the rate of 11 buckets per minute, delivering 48 cubic yards per hour.

The advantages of current-wheelers over steam or electric dredges are: Small first cost; natural motive power; low labour charges. Their disadvantages are: Unsteady work; dependence on a strong current for power; necessity of obtaining current by working well out in the stream, where, during a considerable part of the year, the water may be too deep, or the deposit of silt too great to permit of continuous work; liability of the current being checked or diverted by the tailings piled up by the dredge. Finally, their inability to work near the beaches and eddies, where current is wanting, but where the richest portions of wash-dirt are generally formed.

(*b*) *Steam Dredges.*—The first steam dredge of the bucket type was launched on the Clutha in 1881. Such dredges differ from current-wheelers only in being provided with engine and boiler in place of the undershot wheel. The use of steam machinery, of course, increases the initial cost, adds to the working and maintenance expenses, and necessitates the employment of skilled mechanics. But these disadvantages are, in most cases, largely outweighed by the greater output and the wider utility of such dredges. They can be used in places where there is insufficient current for a wheel dredge; and they are able, when the river is too high for midstream operations, to work along the banks, or run up into the eddies and backwaters, where a minimum amount of silt is being deposited. Hence with the introduction of steam, stoppages have been of shorter duration, and work has proceeded more regularly.

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* "Reports on the Mining Industry of New Zealand," 1895, p. 154.

† *Ibid.*, p. 155.

‡ "Reports on the Mining Industry of New Zealand," 1896, page 154.

(*c*) *Electric Dredges.*—Where water power is available within reasonable distance, electricity may be generated and transmitted by cable to the dredge, proving an economical substitute for steam, especially in localities where fuel is dear. The small space, too, occupied by the plant, and the ease with which it is handled, make electricity a very convenient power for this class of work; and the necessary gear will compare favourably in weight, dimensions, and multiplicity of parts, with any steam plant.*

The following description of the Sandhills dredge, on the Upper Shotover, is taken from the "Lake Wakatipu Mail."† Power for the dredging plant, pumping, and lighting is supplied by two electric generators, driven by water power, two motors being placed on the dredge. The cost of the dredge was £7,000, of which £800 was paid for freight and cartage. The generator station is 3 miles from where the dredger is working. This part of the plant consists of two Brush Victoria generators, driven by an ordinary 4-ft. Pelton wheel. The machines are capable of giving a total output of 52 kilowatts, or 70 h.p. The water for driving is brought from a creek by a 2-mile race. A pressure tank is placed above the generator station, and a line of pipes delivers the water at a pressure of 232 lbs. per square inch. The plant is equipped with a complete set of measuring and controlling apparatus, and connected with the dredge by telephone. The conductors conveying the power to the dredge are carried on patent insulators supported (2 ft. apart) on iron rails, the telephone wire occupying a central

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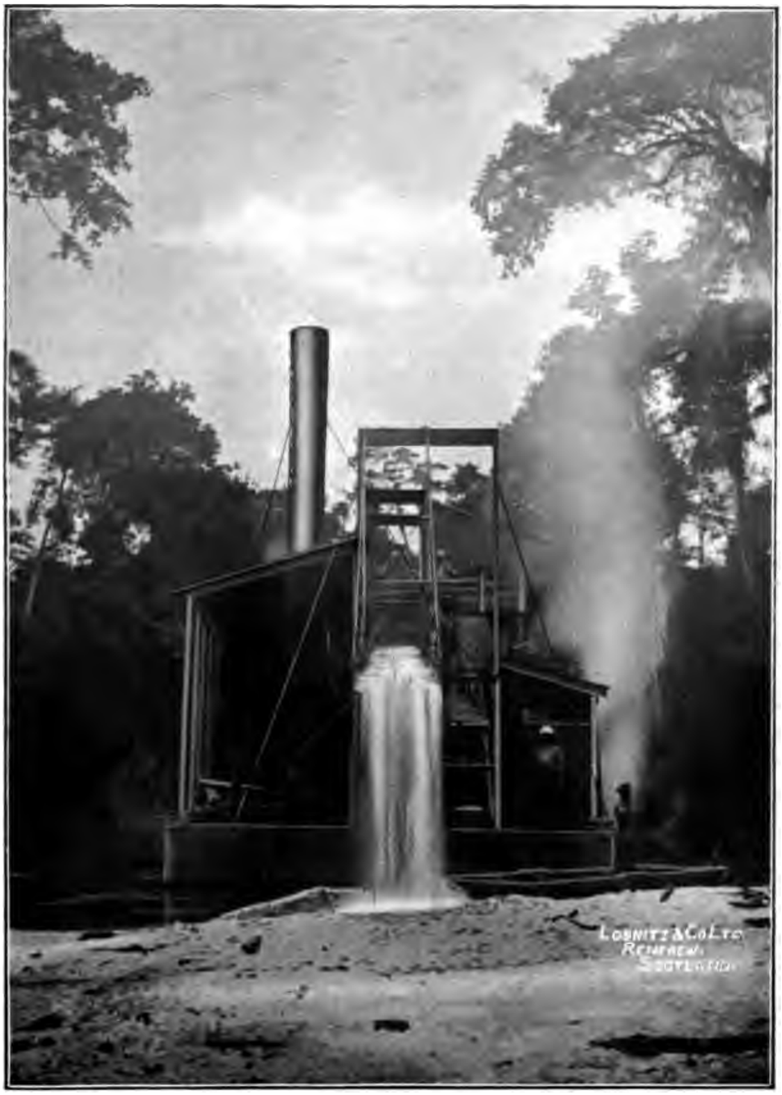
* Mr. Postlethwaite, however, states that with wood at $2 per cord, free on board, a steam dredge can be worked at much less cost than an electric dredge purchasing power at 1½ cents per kw. hour; and, in addition, the repair bill is not nearly so heavy. This, which has been conclusively proved in practice, is due to the enormous reserve power and momentum, in an inductive motor, as against a steam engine. ("Mining Magazine," January 1905, p. 11.)

† "Reports on the Mining Industry of New Zealand," 1891, p. 74; *Ibid.*, 1897, p. 138; also Mr. Robert Hay's Paper, Pro. Inst. of Civ. Eng., Vol. CXXI., Part III.



A Steam Dredger at Work.
Builders, Messrs. LOBNITZ & COMPANY, LIMITED, Renfrew, Scotland. 22-A

position immediately above. It is said that, notwithstanding the heavy current present in the power conductors, no inconvenience is caused, by induced currents, to the telephone line. To prevent damage to the telephone from accidental contact with the power line, an exceedingly fine safety fuse is included in the telephone circuit. The power is conveyed from the land lines by means of flexible cables suspended at convenient height above water. After passing through guide-blocks, the cables are led to revolving drums by means of a revolving connector attached to each drum. There is no interruption in the connexions while paying out or taking in the cable. The two motors are duplicates of the generators, the electrical plant having been constructed specially for the work. The several parts of all the machines are interchangeable, and a spare armature and field magnet are provided in case of accident. A 16-in. centrifugal pump is worked by one motor, and the other drives the buckets, winches, and other gear in connexion with dredging. All the necessary switches, shunt coils, &c., for controlling the machinery, &c., are placed in convenient positions on deck. The pump, main shaft, and counter-shaft are driven by 5-in. rope bands, and have proved to be durable, efficient, and especially adapted to the work of the dredge. The dredge is lighted by two Brush arc lamps of 2,500 candle-power each.

A later illustration of an electrically-driven dredge is the Earnscleugh No. 3, designed by Mr. R. H. Postlethwaite, of the Risdon Iron & Locomotive Works, San Francisco. The main feature is the use of separate motors for every department. Thus there are six motors disposed as follows: One motor driving the bucket-chain, one driving screen and elevator, one operating the ladder winch, one working the head and side-line winches, one driving the sand-pump. The source of energy is the fall of the Fraser River. The pipe-line is about a mile and a-half long, the pipes being 2 ft. in diameter, the pressure at the power-house registering 172 lbs. to the square inch; here a three-phase alternator is driven by a turbine running at a speed of 400 revolutions per minute; the alternator is capable of generating 200 electrical horse-power. The continuous dynamo for exciting the field-magnets of the alternator is driven by a separate turbine; it is a four-pole shunt-wound dynamo. The conductors from the excitor and alternator are brought to the switchboard; those of the latter are provided with safety fuses; one of them is passed through an ampere-meter which measures the current, while a voltmeter is placed in parallel through a small transformer and measures the pressure. The potential difference between any two line-wires is 5,000 volts. The current then passes through the main switch to dredge by means of a pole-line about 3 miles long. On the dredge, the current passes through a transformer and is transformed from 5,000 volts down to 250 volts; the current then passes through the switch-board to the motor; the free ends of the motor coils are connected to a starting resistance. The motor has, at full load, an output of 100 h.-p.; a smaller motor for driving the winch has 25 h.-p. The current for the arc lamps and incandescent lights is passed through a smaller transformer which brings the pressure down to 50 volts.

(*d*) *Turbine Dredges.*—The author knows of only one instance in which a dredge was worked on this principle. About 1889—90 Messrs. Kincaird & McQueen, of Dunedin, constructed for the Ocean Beach Lagoon, West Coast of Middle Island, a bucket dredge worked by a turbine-wheel.* The water was brought from a creek in wrought-iron pipes, but on trial the pipes proved faulty, and the turbine was replaced by steam power.

(*e*) *Pelton-wheel Dredges.*—At Waipori and Cardrona, Mr. W. O'Brien adopted water-power direct for working a small dredge. A Pelton wheel, from which the machinery is driven, is mounted on the dredge. Water under pressure is conveyed in pipes, and, to allow of the movement of the dredge without interfering with the water supply, the pipes between the dredge and the bank are carried on small pontoons, and have ball joints. By this means the varying movements due to height of water and shifting of dredge are met. The disadvantages of wear and tear of the joints might be, and, it is said, have been, removed by the use of armoured hose. The advantages claimed are that engines, boilers, and fuel, with their attendant costs, are dispensed with, and the water used for the Pelton wheel, which is placed at the same elevation as the sluice boxes, is afterwards utilised for washing the material, thereby obviating the necessity of pumping water for this purpose. A small reversible wheel is used to work the winches. On a 3¼ c. ft. capacity bucket dredge running at about 13 buckets per minute, the substitution of water for steam power is stated to have effected a saving of £1,000 per annum.†

3. According to Type.

A type distinction between bucket dredges is sometimes drawn, the two classes being respectively termed the New Zealand and the American. The New Zealand type of dredge is said to lift the material higher and to screen it finer than the American, and, consequently, to be more costly in operation; and, while the former type is manœuvred by lines alone, the latter employs also the spud, by which greater steadiness in work is obtained. The New Zealand dredge largely employs tables for gold saving; but the American relies chiefly on the riffled sluice, and is therefore simpler in operation.

"The type of dredge," says Mr. R. L. Montague, "that is so successful in America is in its main features totally different from the New Zealand type of machine. In the former, the gravel in place is excavated by an endless chain of buckets; in some instances the buckets are connected by links, in others the buckets are continuous. The upper tumbler which drives this chain of buckets is set about 14 ft. above water level. The excavated gravel is dumped into a grizzly placed with its lower end projecting over the side of the boat; and the large boulders drop overboard, and are thus easily disposed of. The finer material that passes through the openings in the screen (these openings average 4½ inches square) falls into a sump, and a centrifugal pump picks up this gravel, together with the water necessary to sluice it, and elevates it into a sluice-box, which is supported on an auxiliary flat boat at the stern of the dredge. It is not necessary to have the upper end of the sluice-box over 20 ft. above water level; the average height taken from a number of dredges operating in various localities is 15 ft.

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* "Reports on the Mining Industry of New Zealand," 1890, p. 85.

† "Reports on the Mining Industry of New Zealand," 1901, p. 25.

"This type of dredge, instead of being held in position by a series of wire cables, is held by means of a 'spud' or anchor, which consists of a timber shod with a steel shoe, or, as is the case in some places, the spud is made up of sheets of steel and channels, I beams, &c. The digging is performed by starting the bucket-chain on one side of the face of the cut, and moving slowly across the face. As the dredge is pivoted on a spud at the stern, only one line is needed to swing the dredge. When the other side of the face is reached, the ladder supporting the bucket-chain is lowered, and the dredge swung slowly back, thus taking off another cut. This process is kept up until bed-rock is reached; then the dredge is moved up towards the face, and the process is repeated. There are several advantages in this method of digging that appeal to a practical man. One point is that the cut is dug out clean, it being impossible to leave any gravel behind. Then, again, the dredge being held steady by the spud, there is practically no surging backwards and forwards of the dredge, as is the case with dredges that are only held by cables. The side-feed makes it easier to keep the buckets full continuously, and, furthermore, cleans bed-rock better than any other method of digging. The only parts of this dredge that are brought in contact with the gravel are the bucket-chain, the revolving screen, and the centrifugal pump.

"The upper end of the sluice box rests on a turntable, the base of which is supported on the dredge; and a short length of special hose connects the end of the discharge pipe, from the centrifugal pump, with the sluice. By this means, a flexible connexion is formed between the dredge and the sluice-box. The lower end of the sluice can be swung into any position, and thus the accumulation of tailings can be regulated and spread evenly across the pit.

"A further advantage of this method of dredging is that the coarse material, being on the bottom and the fine material running on to it, fills up all the spaces between the boulders, and thus packs the tailings well down. The actual space occupied by tailings from a cut, the average depth of which was 35 ft., was 38 ft.

"A properly-designed sluice-box boat will have 50 ft. clearance between the dumping end of the sluice and the stern of the auxiliary flat boat which supports it. This ensures against the tailings crowding in and grounding the sluice-box boat. . . .

"In the New Zealand dredge the upper tumbler is set about 22 ft. above water level; the excavated material is dumped into a revolving screen with very fine openings. The screened material is carried over a set of gold-saving tables extremely limited as to size, and then elevated by means of a centrifugal pump. The coarse material that comes out out of the lower end of the grizzly is about 24 ft. above water level. While it is true that it is not necessary as a rule to run the centrifugal pump that lifts the fine material from the gold-saving tables continuously, we can safely say that this pump is run half the time.

"I will now compare the work done by the two different types of machines.

"The American type lifts 100 per cent. of the material 14 ft. above water level, and after screening lifts, say, 60 per cent., 15 ft. above water level. The New Zealand type lifts 100 per cent. of the material 22 ft., and after screening lifts 60 per cent 24 ft., and 40 per cent. 24 ft. for half the time. The ratio of power expended in lifts alone is 23:42.2.

"In the American type I have put the screened gravel at 60 per cent. of the whole, and as the openings in the screen of the New Zealand type are so much smaller, I have put this dredge's screened material at 40 per cent. of the whole (note, the smaller this percentage is, the more unfavourably does the ratio work out).

"From actual experience I find that an American type dredge, with a chain of buckets of 5 cubic feet capacity, will excavate and sluice on an average 2,300 cubic yards per day of 24 hours. The indicated h.-p. of this dredge was 120. This dredge was driven by electric motors, and the instruments used to measure the power were made by a first-class firm—viz., the Weston Instrument Company, Newark, N.J. This works out at about 19 yards per h.-p. per day. The work done by the New Zealand type I cannot state from actual experience, but taking the figures that have been given me by the advocates of this type—viz., 50 h.-p. for a 3-ft. bucket dredge, the capacity is 600 cubic yards per day on an average. This works out at 12 cubic yards per h.-p. per day. In buying electric power by meter rate, we will presume that a unit of h.-p. costs £1 ($5) per month. The wages we will put at 10s. per day unskilled, and 14s. and 16s. per day for skilled labour.

" The American type will need per shift of eight hours one operator at 16s., one machine tender at 14s., and one deck hand at 10s. The New Zealand dredge will need one operator 16s., and one deck hand at 10s. The total wages and power bill per day will be: American type—wages 120s., power 80s. per day; total, £10 per day. The New Zealand dredge—wages 78s., power 33s. 4d.; total, £5 11s. 4d.

Type.	Wages.	Power.	Total.	Capacity. cu. yds.	Cost per yard for wages and power.
American ...	120/ ...	80/ ...	£10 0 0 ...	2,300 ...	1.04d.
New Zealand ...	78/ ...	33/4 ...	5 11 4 ...	600 ...	2.03d.

" Obviously, the American type of dredge can handle ground more economically than the New Zealand type. When we go into the cost of repairs the comparison is still more unfavourable for the New Zealand type.

" In drawing these comparisons, I have had, on one hand, my own experience as the source of my figures; but, on the other hand, I have had to take figures of those who were interested in the New Zealand type of dredge.

" In regard to the gold-saving efficiency of the American type of dredge, in localities where the gold is coarse no difficulty is experienced, and in other places where finer gold is met with, the introduction of under-currents in the sluice and other devices has successfully accomplished that end."*

The author thinks that the above comparison is not altogether fair to the New Zealand dredge. Many engineers believe that, for general work, the resiliency given by the New Zealand use of the head-line is of material benefit, by reducing the jars or shocks that the dredge must suffer when rigidly held in position by the spud, which allows no give and take. There is also little doubt that the New Zealand system admits of more rapid change of position, since there is no delay in resetting a spud. Again, the system enables the stem of the dredge to be moved independently of the bow. As regards power consumption, it must be remembered that the chief expenditure is, not in lifting the material, but in overcoming the friction of the bucket-belt over the two tumblers, and in actually digging out the gravel. As the belt friction is largely independent of the height of lift, and the power expended in excavating is no function of the lift, the comparison as to power consumed can hardly be so much in favour of the American type as Mr. Montagu contends. It appears also as if in the comparison of costs, maxima had been selected for the New Zealand and minima for the American dredge. The selection of gold-saving appliances is not a question of type, but of suitability to the character of the gold.

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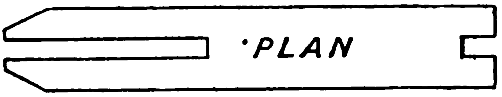
* "The Development of Gold Dredging in the United States," by R. L. Montagu; "The Mining Journal," June 28, 1902, p. 896.

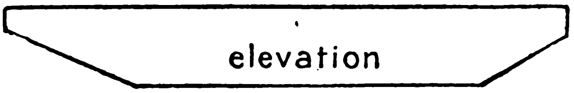
VI.—Details of Bucket Dredge Construction, Equipment, &c.

The Hull.—Among dredging hands, the "hull"—namely, "port" and "starboard" pontoons tied together—is usually termed the "pontoon" or "pontoons." The ordinary hull consists of two long, narrow pontoons, joined together for about a third of their length by a third small one, equal in width to that of the ladder-well required. The two longitudinal sides of the small pontoon are really a portion of the inner or well sides of the two main pontoons. For river work, pontoons should be made longer in proportion to their width than for pond dredging; they are then more easily handled in swift currents.

In all pontoons, the bows should be well drawn in. This enables the corners to be well taken out without bringing the dredge at right angles to the line of advance—a dangerous proceeding in a swift current.



In elevation the pontoons are much shorter on the bottom than on the deck. This allows of working close to the face forward, and prevents the stem being hampered by the tailings from the tables; besides, in a current, the forward end is given a certain amount of lift and buoyancy.



As the pontoons are practically a pair, joined together, great care in the design is necessary to obtain the required rigidity, especially in the cross section, as the greatest strain comes on the inward edges of the well, tending to cause the pontoons to buckle or hogg—that is, to assume a concavity on the deck and a convexity on the bottom.*

The length of the hull, usually from 90 to 110 ft. long, is to a great extent fixed by the dredging depth. This is measured from the water line of the dredge to the cutting edge of the bucket, when the ladder is lying at an angle of 45° to the water line. Some dredging engineers measure what they term the "maximum dredging depth" at an angle of 35°; this makes a considerable difference, and in buying or ordering dredges, it is advisable to have this angle stated.

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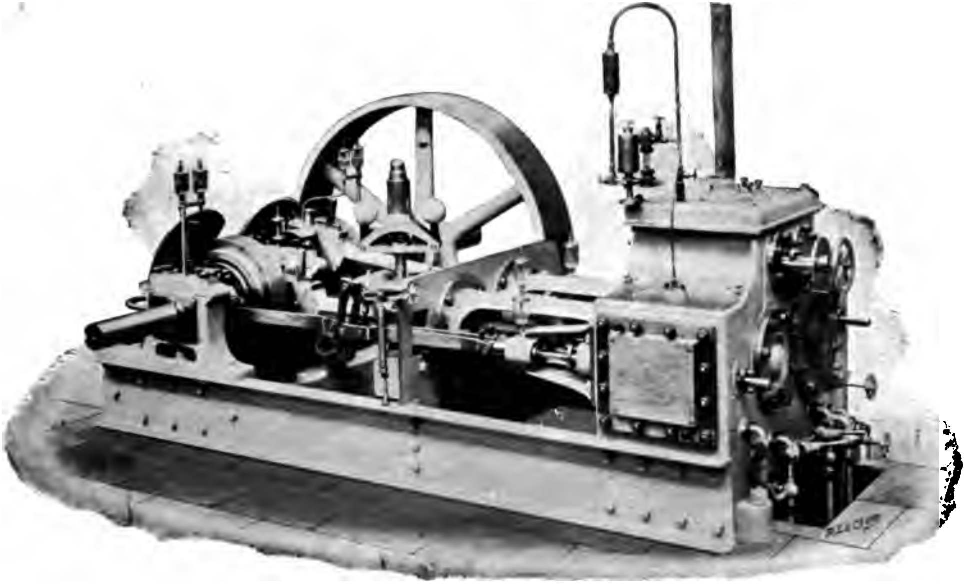
* "Gold Dredging in New Zealand," by C. E. Turner; "The Mining Journal," December 6, 1902.

As regards material, wood has very largely replaced steel and iron. In Australia, timber hulls are exclusively used, also timber superstructure for carrying the machinery. In some dredges, however, steel gantries are used, built of angle bars and plates. The timber for the hull framework, planking and deck is colonial hardwood. In a number of instances, oregon, and, in some cases, kauri has been employed for planking and decking. Where, owing to white ants and other destructive insects, it would not be advisable to use timber, it would be necessary to adopt iron and steel. For several reasons, steel is the material to be used in South Africa for hull construction. In New Zealand, the hull material is mostly Australian hardwood, chiefly blue gum, with kauri for planks and deck.

The main point in hull construction is stiffness to resist the concussions and jars the dredge has to withstand. Immense hardwood logs, 60—70 ft. long, with a mean diameter, perhaps, of 4 ft., firmly embedded for years in the wash, have to be lifted and carried clear of the dredge; huge boulders have to be negotiated; floods, at times rising 30—40 ft., rushing past at perilous pace and carrying islands of *débris*, have to be withstood, so that strength and stiffness are essential. Rigidity is increased by heavy transverse beams running across the width of the three pontoons and lattice braced, so as to overcome the tendency of the structure to "sag" or "hogg." Various methods employed in hull-building are known as double skin, fore and aft keelson, braced stringer, wedged stringer, girder side, cellular type, &c. All adopt lateral (athwartships) stiffening by diagonal or cross-bracing. Hold pillars are provided to support the weight of the deck and machinery; and the pontoons are sub-divided into water-tight compartments, in such a way that the filling of one, or even two of them may not sink the dredge.

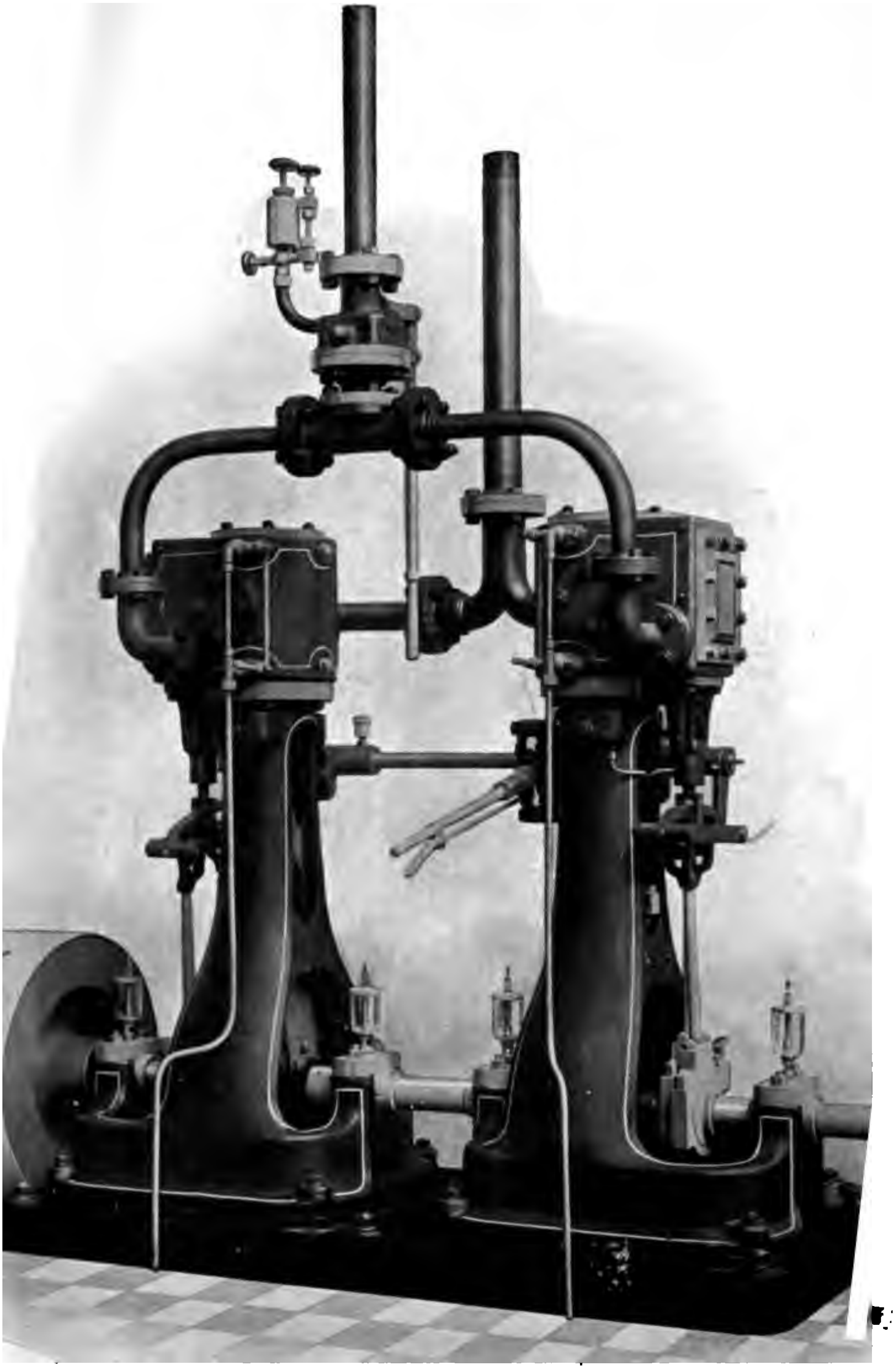
For ventilating purposes, the usual appliance is a sheet-iron casing with doors, applied to the ashpit of the dredge boiler. The ashpit is thus connected with the inside of the pontoon by means of openings cut in the deck, and the draught required for the boiler-furnace passes through the pontoons and may be controlled from any part. Adequate ventilation of the interior of wooden pontoons is very essential.

The Engines.—Very many of the engines and boilers on New Zealand dredges are from the works of Messrs. Marshall & Sons, Limited, Gainsborough, Lincolnshire, England, who make a speciality of steam plant for dredging purposes. The main engines are mostly



Compound Independent Fixed Engine.—Built by Messrs. Marshall, Sons, & Company, Limited, Gainsborough, England.

The illustration represents a Left-hand Engine ; unless otherwise specified, engines of this type, with the fly-wheel on the side shown, are supplied.



ontained, Vertical Engines, Coupled.—Built by Messrs. MARSHALL, SONS, & COMPANY, LIMIT
Gainsborough, England.

horizontal high-pressure compound, surface condensing. The illustration shows one of Messrs. Marshall & Sons' independent compound type. These engines are of extra strength throughout, and are suitable for a working pressure of 140 lbs. per square inch. They are provided with Hartnell's automatic expansion valve gear to the high-pressure cylinder; the cylinders are steam jacketted, an automatic sight feed lubricator is provided on the high-pressure cylinder, and a steam trap for draining the cylinder jackets. The crankshaft is of steel, of special length so as to leave room for pulleys for driving the dredge machinery, and balanced cranks and central bearing are included, as well as an outer bearing "A" standard beyond the flywheel, also a simple reversing gear.

As will be seen from the illustration, the entire engine is mounted on a steel frame, eminently suitable for dredges. A large number of these engines are at work on dredges in New Zealand, Australia, Siberia, North America, South America, Africa, Borneo—in fact, wherever gold dredging has been introduced, and they are giving out excellent results.

The following are particulars of the more usual engines supplied by Messrs. Marshall for dredges:—

COMPOUND STATIONARY STEAM ENGINES.

8 to 35 h.-p. with Hartnell Governor. 40 h.p. and upwards with Proell Governor.

HORSE POWER.			CYLINDERS.			Revolutions per Minute.	Diameter of Fly Wheel.
Nominal.	Effective h.-p. at 140 lbs.	Indicated h.-p. at 140 lbs.	High Pressure Diameter in inches.	Low Pressure Diameter in inches.	Stroke.		
12	36	42	7	11¼	14	155	5 ft. 0 in.
16	48	56	8	12¾	14	155	5 „ 6 „
20	60	70	9	14	16	135	6 „ 0 „
25	75	87	10	16	18	120	7 „ 0 „
30	90	105	11	17½	18	120	7 „ 0 „
35	105	122	11½	18	18	120	8 „ 0 „
40	120	140	13	21	24	90	9 „ 0 „

A substantial form of self-contained engine is made by Messrs. Fraser & Chalmers. The condenser air-pump is driven by an eccentric from the crankshaft, which is extended to take the driving pulley, and an outer bearing is supplied to withstand the heavy strains.

Independent engines, usually a pair of vertical coupled reversing engines, are provided for the winch. The usual type supplied by Messrs. Marshall's is here illustrated. These engines are provided with link motion reversing gear, enabling the motion of the engines to be instantly reversed by means of a lever under the handy control of the driver, steam jacketted cylinders, specially long and strong steel crankshaft with extra large bearings, one flywheel suitable for giving off the full power of both engines, and, if desired, the engines can be mounted on a cast-iron baseplate.

The Boiler.—The Marshall boilers, specially designed for the purpose, are a combination of the Cornish and locomotive types, requiring no brickwork. The portions, circular throughout, are of two diameters, the larger of the two being at the furnace end, and diminished by curved plates to the smaller-diameter shell, the object being to reduce both the weight of the boiler and contained water, as well as to allow for the unequal expansion which comes on the Cornish type, when fired straight through, without returning the flue to the bottom. That portion of the shell which is largest in diameter carries the furnace, which terminates in a tubeplate; from this plate, a number of loco-boiler tubes pass through the smaller-diameter shell to another tube-plate at the smoke-box end. The smoke-box is filled with the usual door and a funnel about 25 ft. in height. This type of boiler is well suited for hard water and inferior rough wood fuel.

Messrs. Fraser & Chalmers manufacture two types of boilers for use on dredges. Both types are iron cased and self-contained. As will be seen from the illustration, the water-tube boiler occupies but small deck-room. The other type illustrated is a battery of underfired multitubular boilers, so arranged as to be readily installed on a pontoon. To prevent stoppage of the dredge by failure of the water feed, the boilers are provided with a hand-pump in addition to injector and steam feed-pump.

Pumps.—(*See* "Water required for Washing," &c., p. 65.)

The Winch is compound, having at least six barrels or drums with clutches, friction brakes and levers, and is so arranged that the winchman, without moving more than a step or two, can work any one or more of the barrels in either direction. One barrel carries the galvanised wire rope, which, passing over the gantry and through a compound sheave, is used for raising or lowering the ladder; a second barrel is for the head mooring line, and the other four barrels are connected with the four side mooring lines. Many winches have a seventh barrel, which may be used for lifting heavy weights, or, in case of flood, for working a spare head line. The different makes of winches used are essentially of one type. In a dredge, built in Dunedin for work in Central Siberia,* the winches have the usual four barrels for the side lines, a barrel for the ladder-lifting line, and two barrels for the head lines, one in case of emergency. But in addition to these seven barrels, there is a surging drum for odd purposes. Any one of the eight barrels can be used separately, or the whole eight can be worked at the same time by one man. Winches

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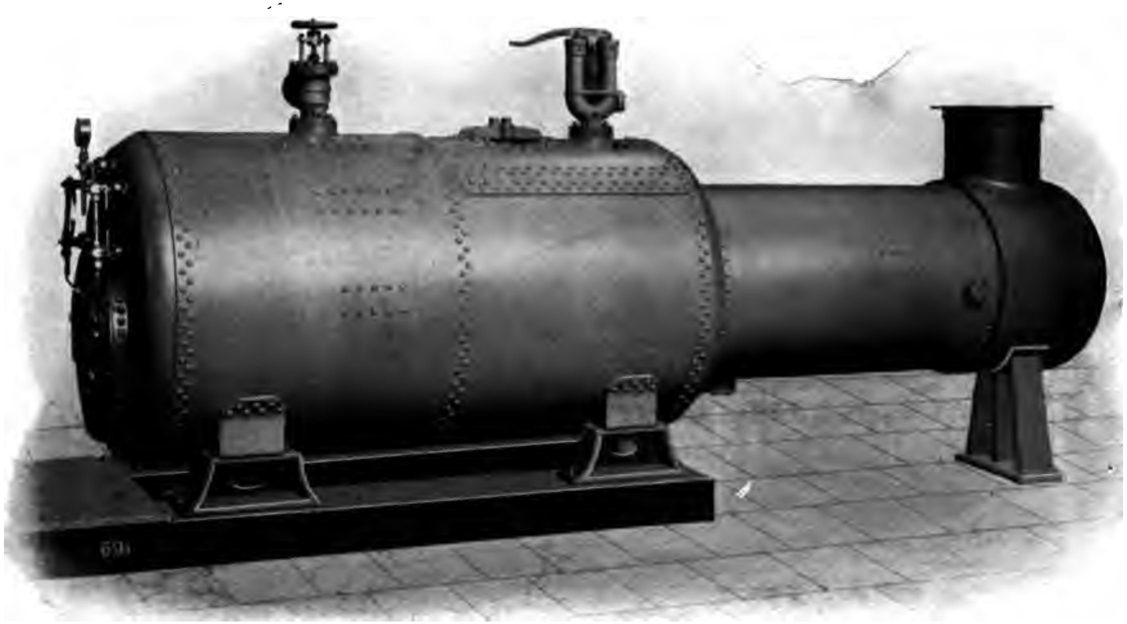
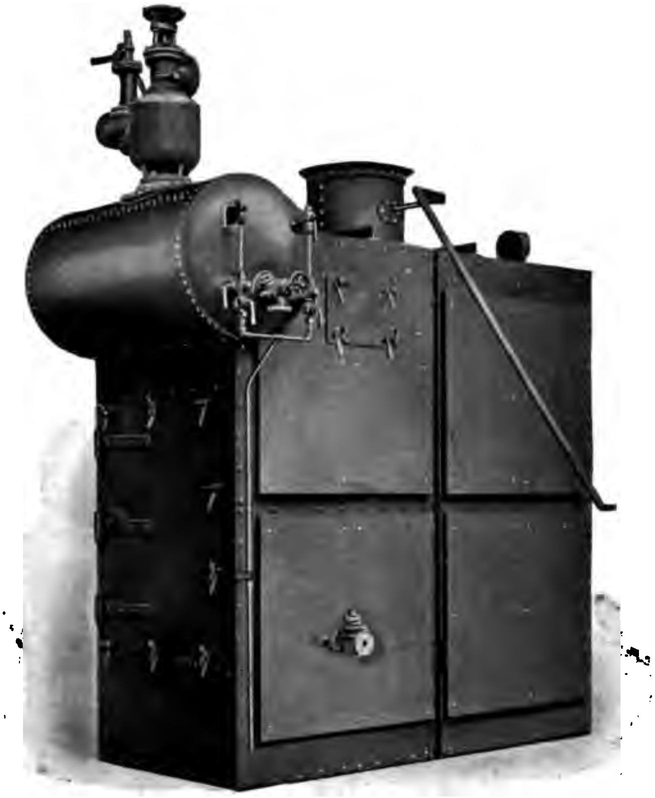
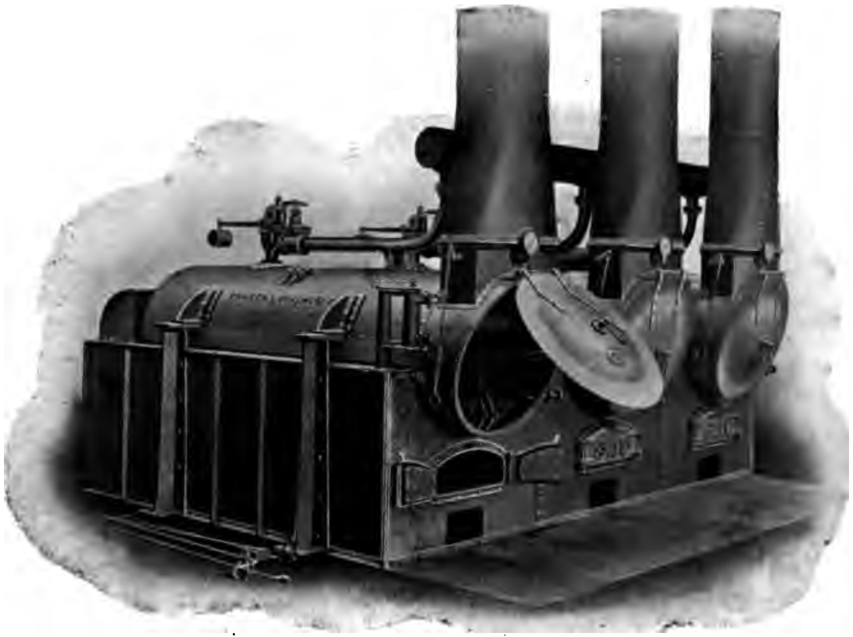
* "Reports on Minerals and Mines, New Zealand," 1899, p. 152.



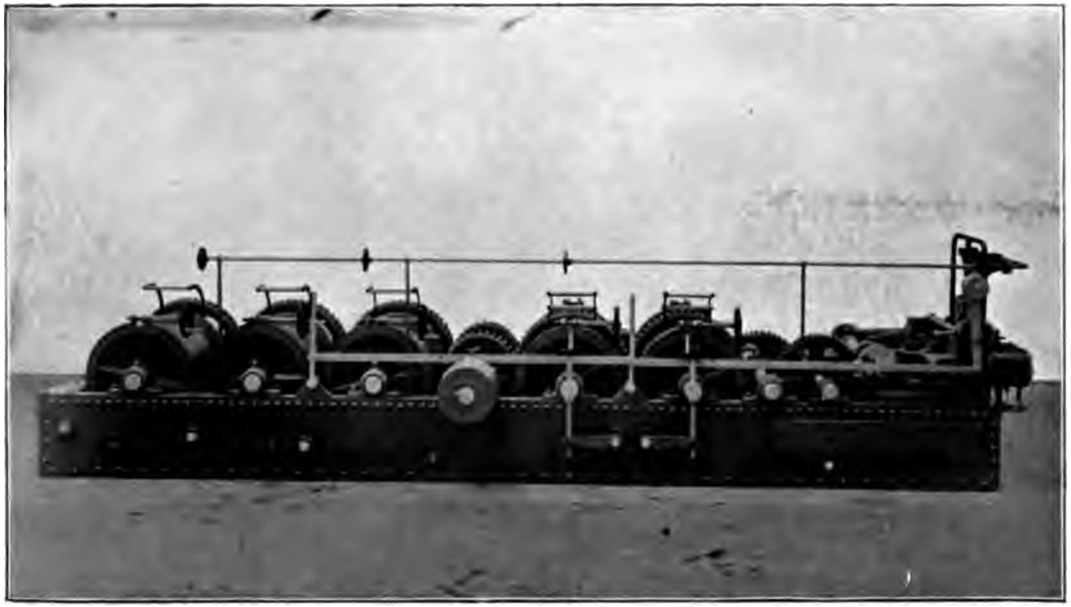
Special "Dredger" Boiler.—Built by Messrs. MARSHALL, SONS, & COMPANY, LIMITED, Gainsborough, England. 32—A



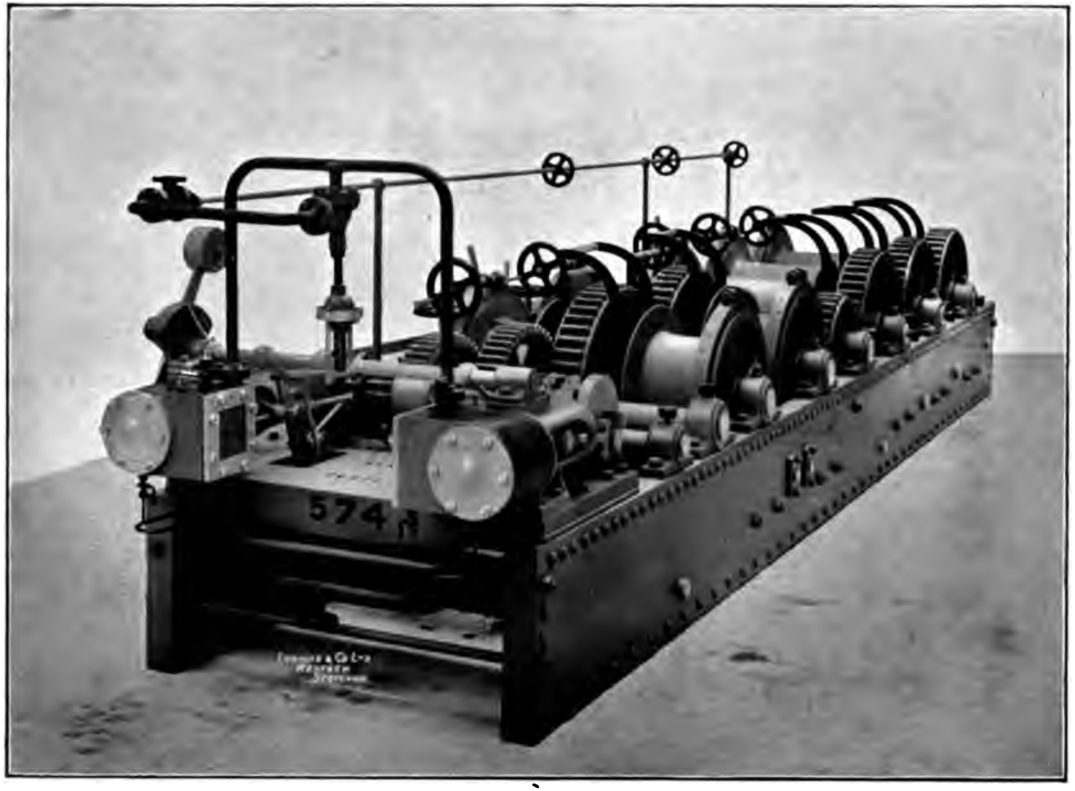
Water-Tube, Iron-Cased, Dredge Boiler.—Built by Messrs. FRASER & CHALMERS, LIMITED, Erith, England.



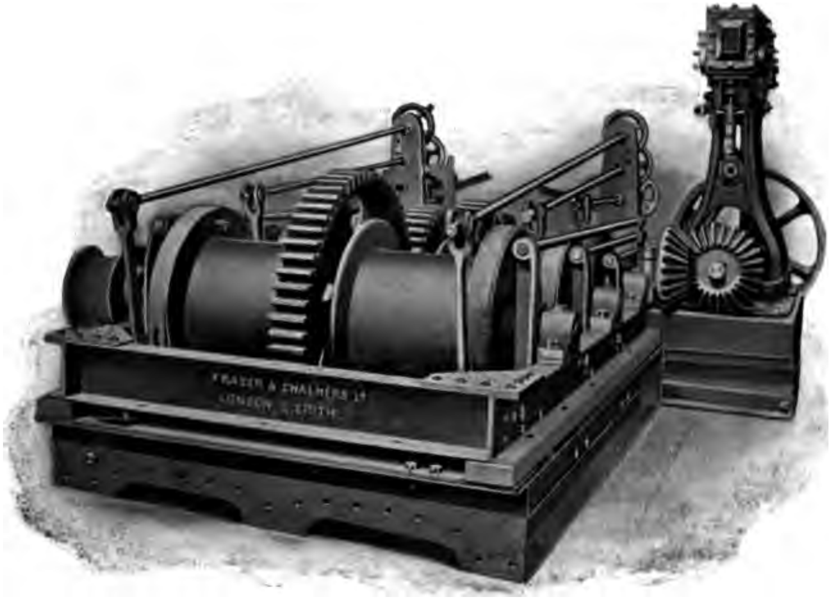
Underfired Multitubular Dredge Boilers.—Built by Messrs. Fraser & Chalmers, Limited, Erith, England.



Seven-Barrel Dredge Winch (side view).—Built by Messrs. LOBNITZ & COMPANY, LIMITED, Renfrew, Scotland.

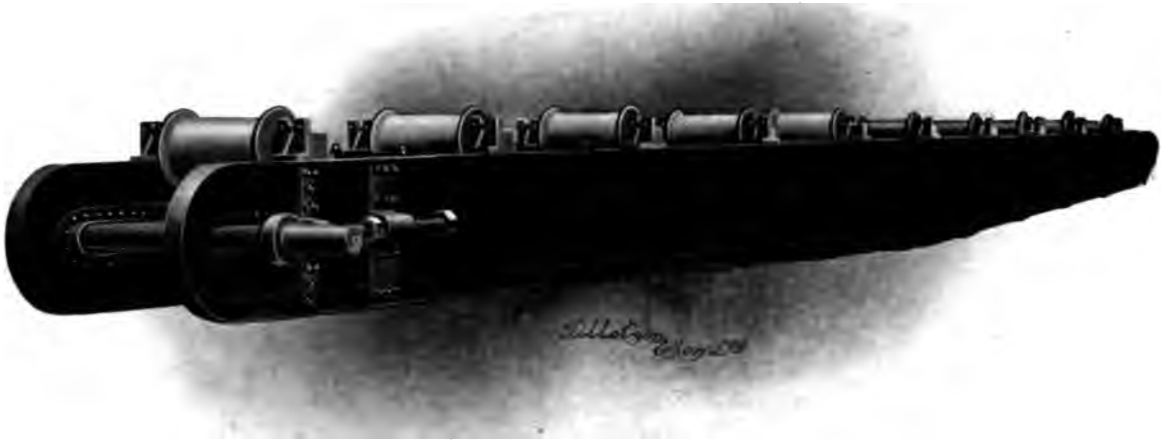


Seven-Barrel Dredge Winch (end view).—Built by Messrs. Lobnitz & Company, Limited, Renfrew, Scotland.

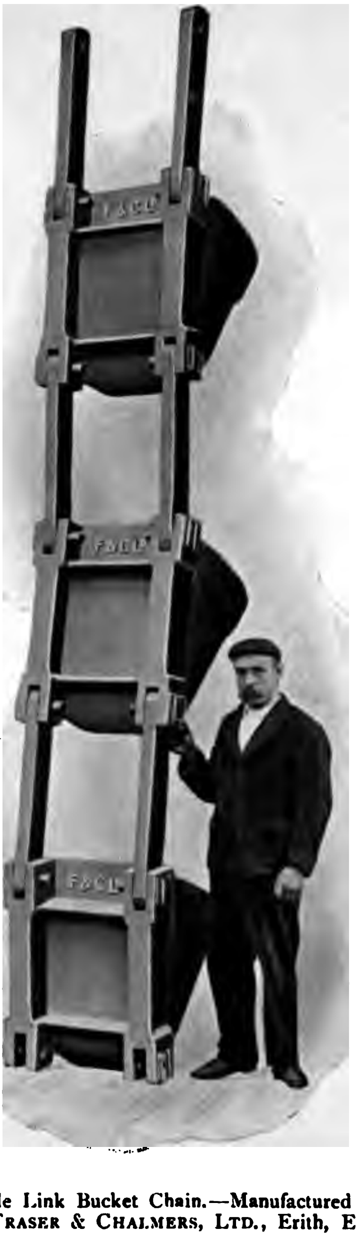


Type of Steam-driven Dredge Winch.—Built by Messrs. FRASER & CHALMERS, LIMITED, Erith, England.

32—F



Dredge Bucket Ladder.—Built by Messrs. LOBNITZ & COMPANY, LIMITED, Renfrew, Scotland.



Single Link Bucket Chain.—Manufactured by
Messrs. FRASER & CHALMERS, LTD., Erith, England.

32—H

should be very strongly constructed, with the gearing shrouded on both sides of the teeth, and with the barrels of ample diameter and size for the lines employed.

Bucket Ladders.—Are usually built of angle iron and steel plates, less frequently of wood. In length they vary from 40 to 85 ft. It has been found that a ladder angle of 45° is most satisfactory for working the buckets; for when the wash is compact and requires to be torn out, the buckets should be well ahead of the pontoon. With loose wash, readily falling into the buckets, the inclination of the ladder may be much steeper. As in working it may be desirable to alter the angle, the more recent ladders are sometimes fitted with a telescopic arrangement by which the ladder can be lengthened or shortened some 3 or 4 ft.

The Buckets.—Buckets, which now vary from 3½ to 7 cubic ft.* capacity, are built in various ways. In some cases the bottom or base is of the toughest, Swedish or Scotch, cast iron. Attached to this base are steel sides, fitted with a lip of the hardest steel. In other cases, they are built entirely of steel plate, and are rivetted on to usually one row on each side, of steel links, bushed with manganese steel, of which also the pins are made (*see* illustration, p. 34). Buckets of annealed Bessemer steel, with rim and wearing parts rivetted on, also are used.

The shape and size of the buckets must be regulated by the class of wash to be treated. Those of rounded lips resist crushing better than flat lips, but they do not clear up the bottom so well. The buckets are provided with renewable lips of nickel steel or of manganese steel, but great care is required in making this latter, to insure uniform harness.† Lips frequently crack transversely with little or no wear, causing loss of time and money in repairs. Size is not always desirable in buckets. In heavy wash small buckets will sometimes pay, where large buckets would eat up any surplus in repairs.

The patent elevator buckets of F. W. Payne, Dunedin, are said to work with less wear and tear and greater freedom from breakdown than the ordinary buckets.‡

The rate of discharge varies from 12 to 15 buckets per minute, for close-, and from 18 to 28 for open-connected chains.

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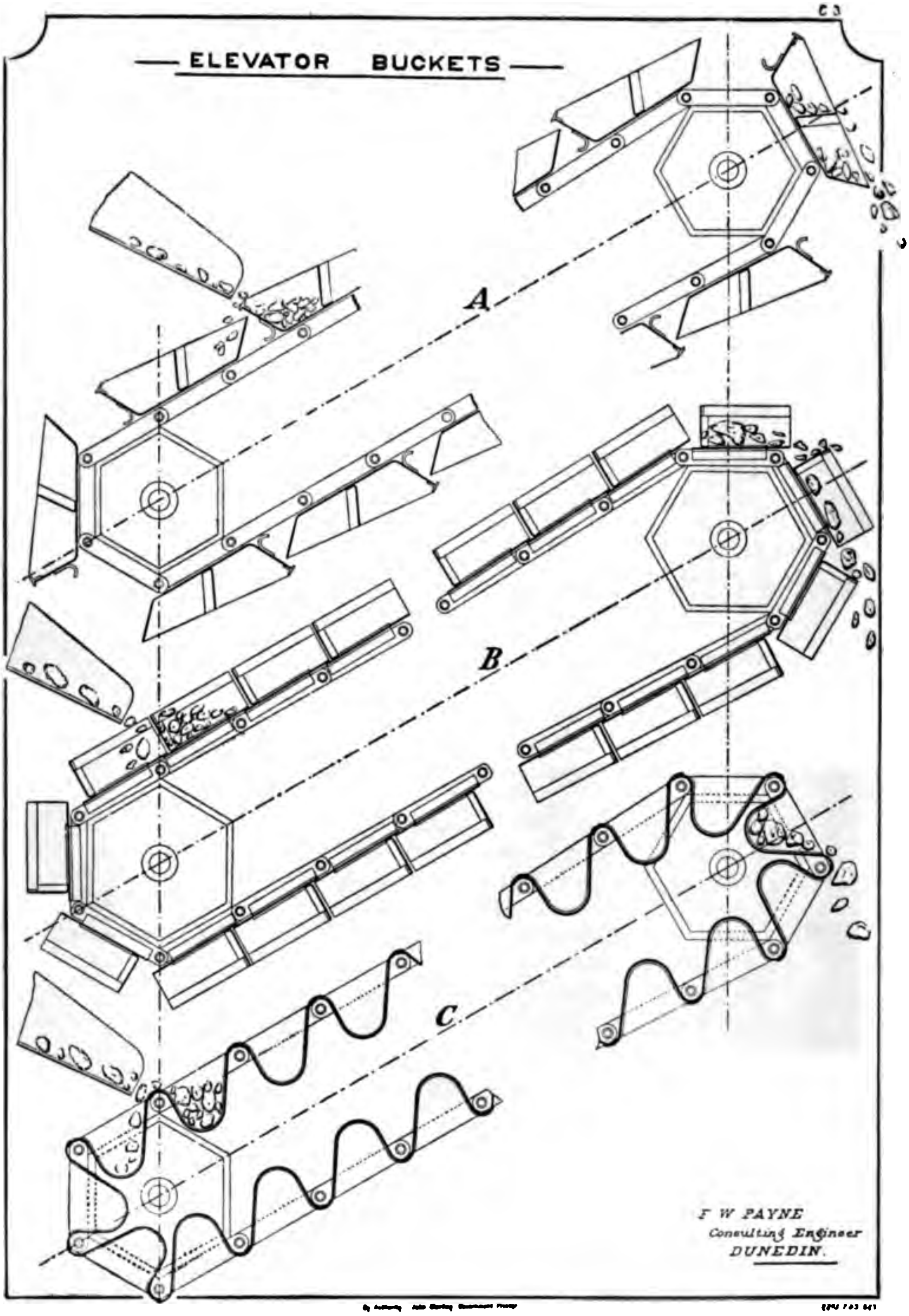
* The advantages of a large bucket are increased yardage, with practically the same labour, the possibility of handling bigger boulders, a less than proportional increase of power and general expense, and probably a less than proportional increase in the cost of repairs. The disadvantages are—a greater first cost, the necessity for special facilities for handling the heavy dredge parts when making repairs or renewals, and the increased difficulty of washing the large and highly irregular amount of material delivered by the buckets to the screen.

† For manganese steel, Messrs. Hadfield's Steel Foundry Company, Limited, Sheffield, has a world-wide reputation.

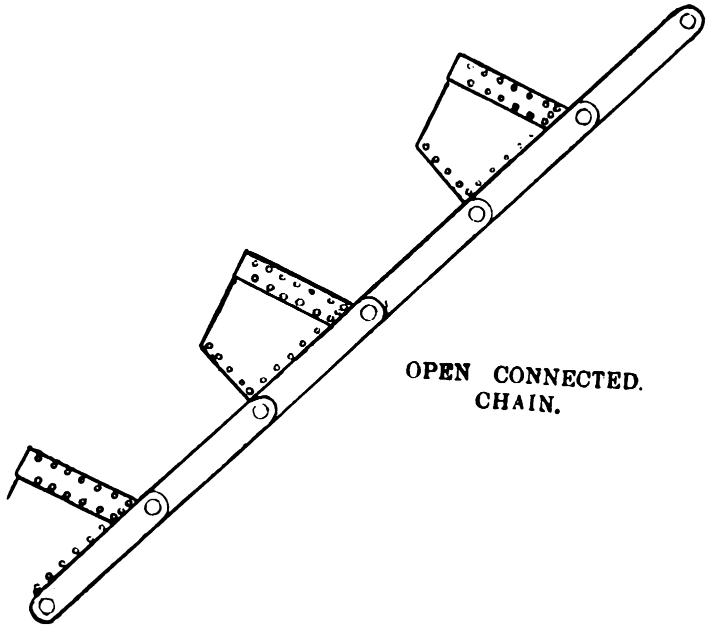
‡ "Reports on Minerals and Mining, New Zealand," 1903, p. 13.

ELEVATOR BUCKETS

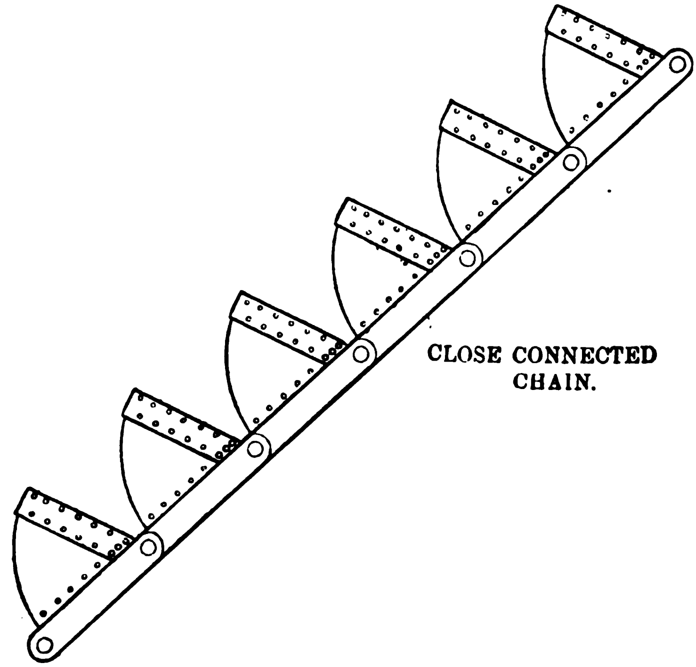


F W PAYNE
Consulting Engineer
DUNEDIN.

By Authority: John Mackay, Government Printer.



OPEN CONNECTED.
CHAIN.

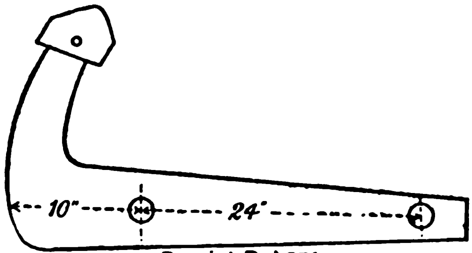


CLOSE CONNECTED
CHAIN.

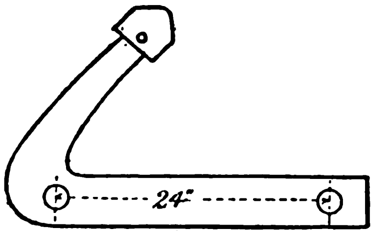
PES OF BUCKET CHAINS.

Buckets may be connected together, so as to form a chain, in two ways—with intervening links, forming "open-connected chain"; by pins and bushes, without links, forming "close-connected chain (*see* illustration, p. 35). For hard digging, Messrs. The Risdon Ironworks recommend open-connected buckets.*

Grab-hooks.—In addition to buckets, the chain is frequently provided with two or more pairs of grapnels, or grab-hooks. These hooks are of two kinds, the ordinary hook being much the same form as a bucket. The sketches will explain the difference between the two hooks, and the position of the pin-holes.



Davis' Patent



ordinary

The construction of the Davis grapnel is such that on reaching the tumbler, the hooks project past the line of the bucket-lip and tear into tight gravels, thus acting as a pick. On leaving the tumbler they recede within the line of the lips. Grab-hooks serve not only to break down ground, but also to raise boulders too large for the buckets.

Transmission and Gearing.—The power is best transmitted from the engine to the machinery by belting or rope, which absorbs all shocks due to the unequal strains put upon the machinery by the

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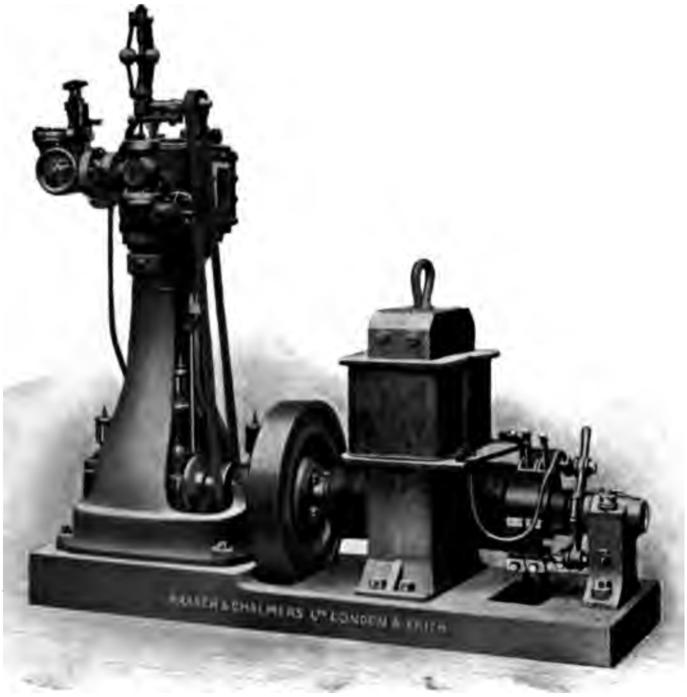
* Both intermittent and close-connected bucket lines are in use, but the close-connected type, as a rule, finds more favour among operators. It is claimed—and it is undoubtedly true—that the intermittent line can be run faster and that the buckets fill better; but, as there are only half as many buckets for the same number of links, the dredging capacity is less. An intermittent bucket line will handle larger boulders than a close-connected one, and is to be preferred in some cases for this reason." ("Gold Dredging at Oreville," by H. D. Smith and E. W. Stebbins. The "Engineering & Mining Journal," December 8, 1904.)



Type of Electric Light Equipment, supplied by Messrs. FRASER & CHALMERS, LIMITED, Erith, England. 36—B

buckets dredging in rough ground. The centrifugal pump also is belt-driven. Owing to the enormous wear and tear, due to the attrition of the sand or stones, all wearing surfaces should be provided with hard metal or steel liners. Where possible, bearings should be rendered sand-proof by providing an annular groove, next to the stuffing-box, and supplying this groove with a jet of water under pressure, so as to exclude sand and grit. Ladder transmission gear is fitted with a friction device, for stopping the top tumbler revolving when the buckets catch or the chain breaks.

Mooring Lines, &c.—These are usually wire cables, in number and size as follows:—

2 Stern side lines	2 ins. in circumference.
2 Bow side lines	2½ „ „
1 Head line	3½ „ „

Besides these, there is the ladder line, for raising and lowering the ladder; this is about 3 ins. in circumference. These sizes vary according to size and design of dredge. They should be made of the best flexible steel wire. The lengths run about 50 to 60 fathoms for side lines, and 100 fathoms for the head line.

Lights.—For continuous work by night, powerful fore and aft and other other auxiliary lights are needed. For this purpose electricity, acetylene, and oil are all in use.

General Remarks.—As typical of New Zealand practice in dredge operations, Mr. C. E. Turner gives the following data:—

Bucket travel	from	10 to 24 buckets per min.
Screen revolutions	„	12 to 20 per min.
Elevator trays	„	55 to 75 „ „
Pump revolutions	about	600 „ „
Screen pitch	from	¾ in. to 1¾ ins. per ft.
Screen table pitch	„	1¼ in. to 2 ins. „ „
Outer tables	„	1 in. to 2 ins. „ „
Angle of elevator from horizon		23°—30°

VII.—Horse-power required in Dredging.

In calculating the horse-power consumed by suction and by bucket dredges, figures have been taken from the various official reports on the mining industry in New Zealand, dates and pages in each instance being given. The calculations are made in theoretical horse-power, and for easy references are given in tabular form. The difference in the weight of the gravel lifted, while under the water level, has been disregarded; and, in estimating the steam power in compound engines, it is assumed that the low-pressure develops the same power as the high-pressure cylinder.

These results cannot be called conclusive, but they serve to show: (1.) That the frictional losses of power in gold-dredging are very great, probably 600 to 700 per cent. of the power theoretically sufficient to do the lifting work. (2.) That in bucket dredges, the actual engine power is roughly seven times that theoretically sufficient to do the work. (3.) That the suction dredge, working in exceptionally favourable circumstances—namely, where 95 per cent. of the material to be lifted was fine gravel—consumed 94.4 horse-power on the 47,745 foot-pounds of work required to raise 35 tons of solid material through 35 ft., together with the necessary water through 15 ft., while the Sew Hoy bucket dredge needed only 67.7 horse-power for the 54,130 foot-pounds of work necessary to raise 50 tons of solid material through 29 ft., and the necessary water through 15 ft., and the Kanieri dredge took only 107 horse-power to accomplish the 83,400 foot-pounds of work, representing the raising of 75 tons of solid material through 30 ft., and of the necessary water through 15 ft. It is, therefore, evident that, even in favourable circumstances, the suction dredge in gold dredging requires considerably more power than the bucket dredge, the excess being largely due to the large quantity of superfluous water lifted with the gravel. In proportion as the material becomes coarse, the consumption of power, of course, becomes greater. Mr. J. B. Jaquet, in his "Notes on Gold Dredging," 1898, states: "As an instance of the costliness of the process (gold dredging by suction pumps), I may mention that a suction dredge, working upon the Waiparapa Beach, near the mouth of the Mataaura River, was found to require 60.7 h.-p. to lift on an average 15 tons of gravel per hour, whereas a bucket dredge of 30.7 h.-p. would lift many times this amount in the same time."

The accuracy of the ratio established by the Table (see page 40) between the theoretical power required in the engine and the theoretical work to be done, expressed by the constant 7, may be tested by the coal consumption in the following cases.

Millar's Creek dredge,* with an output of 60 tons of solid material per hour, was fitted with an 18 h.-p. nominal engine for dredging, and a 10 h.-p. nominal engine for pumping—in all, 28 h.-p. nominal. The coal consumption was 326.6 lbs. per hour. Allowing 5 lbs. of coal per indicated horse-power, the total consumption represented about 65.3 indicated horse-power. Assuming the gravel, in this and the following cases, to have been lifted 30 ft., and the water to have been of normal quantity, and to have been raised 15 ft., the theoretical horse-power sufficient for the work would be about 9.3. The ratio between engine-power and work, therefore, in this instance, was very slightly over 7.

The Le Grand dredge, raising 50 tons of gravel and the normal quantity of water, consumed 280 lbs. of coal, representing 56 indicated horse-power, on a consumption of 5 lbs. per indicated horse-power per hour. Taking the height of lift as before, the horse-power theoretically sufficient for the work would be 8.5, giving a ratio of 6.6 between engine-power and work.

The Clyde dredge, raising 50 tons of gravel per hour, had the same coal consumption as the Le Grand, consequently the ratio was the same.

The Enterprise, lifting 75 tons of gravel per hour, was fitted with a compound 35 h.-p. nominal engine, burning 1/8 ton of coal per hour. In this case the coal consumption may have been somewhat less, say, 4 lbs. per indicated horse-power per hour. The total consumption, would, therefore, represent 70 indicated horse-power. The horse-power theoretically sufficient to raise the gravel and water was 11.6, which gives a ratio of rather over 6.

Messrs. Priestman state that in grab or clam-shell dredges lifting 50 tons per hour, the coal consumption is 2 lbs. per ton lifted per hour through, say, 30 ft. total lift. This does not include raising the necessary water for washing, and the output is calculated for favourable ground; the coal, too, is probably better than that in the foregoing estimates.

Steam-dipper dredges, including the driving of the pump for raising the water, probably require about twice the power per ton lifted as the bucket dredge. Hand-dipper dredges are operated by two or four hands at the winch.

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* "Reports on the Mining Industry of New Zealand," 1895, p. 153 *seq.*

TABLE I.—SHOWING THE THEORETICAL

S = Suction Dredge.

Name and Type of Dredge.	Type of Engine.	Diameter of Cylinders.	Stroke.	Revolutions per Minute.	Steam Pressure in Pounds	Cut off.	Mean Pressure.	Horse-power of Engine.	Solid Material Raised per Hour in Tons.
		in.	in.						
Welman, S. ...	Two cylinder horizontal	10	16	125	80	$\frac{3}{8}$	59.6	94.4	35
Sew Hoy Company, C.B., 1892, p. 91	Compound	10 high ? low	16	120	16	$\frac{3}{8}$	44.5	67.7	50
Kanieri, C.B., 1892, p. 99	No. 1 compound	7 high 14 low	14	120	80	$\frac{1}{2}$	67.7	44	75
	No. 2 compound	7 high 14 low	14	200	80	$\frac{1}{2}$	67.7	63	—
Waipori, C.B., 1893, p. 129	Compound	8½ high 16 low	17	194	50	$\frac{1}{2}$	42	42.5	—
Sandbills, C.B.	—	—	—	—	—	—	—	70	—

Horse-Power used in Dredging. (See page 38.)

C B = Centre Bucket Dredge.

Height of Lift in Feet.	Equivalent Work in Foot-Pounds per Minute.	Water Raised per Minute in Pounds.	Height of Lift in Feet.	Equivalent Work in Foot-Pounds per Minute.	Total Work in Raising Gravel and Water in Foot-Pounds per Minute.	Theoretical H.-P. Required in Raising Water and Gravel.	Remarks.
35	47,745	22,500	15	337,500	383.245	11.6	This shows that to overcome friction and work the separating plant, &c., 82.8 h.-p. was required; that is about 713 per cent. of the theoretical power needed to raise the actual weight.
29	54,130	15,000	15	225,000	279,130	8.5	Thus, in friction and in doing other work, 59·2 h.p. was absorbed, or about 697 per cent. of the theoretical power needed to lift the gravel and water.
30	83,400	—	—	—	383.400	11.6	No. 1 engine worked the dredge, and No. 2 drove the centrifugal pump. In this case it required 44 h.-p. for the dredge, and 63 h.p. to raise the water for washing—in all 107 h.p. Of this 95·4 h.p. was absorbed in friction, &c., or 822 per cent. of that theoretically needed to raise the water and gravel.
—	—	20,000	15	300,000			
Total work in raising gravel and water, 384,000 foot-pounds per minute.					—	11.6	The power needed to overcome friction, &c., was in this case 30.9 h.p., or 266 per cent. of that needed to raise the gravel and water. This seems very low; possibly a separate engine, or revolving buckets, were used to raise the water.
Total work in raising gravel and water, 352,880 foot-pounds per minute.					—	10.6	This leaves 59·4 h.p. to overcome friction, &c., or 560 per cent. of that required to lift the water and gravel.

In the foregoing table, the ratio of the actual horse-power used to that theoretically needed for raising the gravel and washing water works out roughly at 7 to 1.

Both Messrs. Marshall, Sons, & Co., Limited, and Messrs. Lobnitz, Limited, consider that the working conditions are too variable to admit of any formula for the ready determination of the horse-power to be provided, and that each case must be dealt with on its requirements. Mr. P. R. Goedkoop, the London representative of Werf Conrad, Limited, of Haarlem, Holland, in reply to an inquiry from the author, wrote:—

"A special formula does not exist, but generally the horse-power is calculated as follows:—

"When you take the number of buckets and the capacity of each bucket, you get a theoretical figure for the production.

"But the real production (the quantity of soil that passes through the screen) is only two-thirds of the theoretical production.

"For all the machinery—that is, the dredging gear, screen, tailings elevator, and pump—the winches excluded, we take as rule 1½ i.-h.-p. for each cubic metre of soil to be washed.

"For instance: A gold dredger has buckets of a capacity of 140 litres each, and the buckets run with a speed of 9 to 10 per minute; then the theoretical production is 80 cubic metres per hour.

"But the real quantity to be washed is only two-thirds of 80 M^3, or about 50 M^3 per hour.

"Therefore you want 50 × 1½ = 75 i.-h.-p.

"When the dredging gear, screen, elevator, and pump are all driven by the same engine, then 70 i.-h.-p. would be sufficient, as all these parts never use their maximum power at the same time.

"But when you have a separate engine for the pump, then the total i.-h.-p. will be more than 75 i.-h.-p., because the pump takes 35 i.-h.-p. and the engine for dredging gear elevator and screen 45 i.-h.-p., together 80 i.-h.-p., or a little more than the 75 i.-h.-p. calculated before.

"All those figures are calculated, taking that the pump has to produce a quantity of water ten times the quantity of the soil to be washed = 10 × 50 = 500 M^3.

"When you have very hard ground or clay you want more water, which increases at once the i.-h.-p.

"Of course, there are always circumstances to be considered special with gold dredgers, when each dredger is designed to suit the ground to be worked, and that is the reason that there is not a more definitive formula as given above."

VIII.—Separation of the Material Dredged.

VERY perfect separation of the material dredged is essential to the successful saving of its gold. In the early days of dredging, attention was mainly directed to increasing the lifting capacity of the dredge, while but very little thought was given to the equally important question of recovering the precious metal. This tendency was largely due to the fact that the dredges were mostly in charge of mechanics, imperfectly acquainted with the methods of recovery. It thus took time to demonstrate the impossibility of saving gold as fine as that in the drift wash of ocean beaches and of river beds, if the material were rushed through narrow sluices, with a large stream of water. This fact, also, was not at once appreciated, that if a large percentage of the fine gold is to be saved, the big stones and coarse gravel must first be parted from the silt. Many dredging ventures have undoubtedly failed through neglecting separation, and through acting on the fallacious principle that by hastily sluicing unsorted material, even if gold is lost, the greater quantity treated will more than compensate for the imperfect recovery. Such a method might, indeed, hold good if the gold were coarse and heavy; but in beaches, and, generally, in river beds, the gold, by long attrition, has been ground into fine dust and minute scales, and to save a fair percentage requires very careful treatment. Good returns, therefore, are impossible without complete separation as a preliminary to further treatment. Without this, the gold is raised, carried through the dredge, and re-deposited in the river. That such a result has frequently taken place might be proved by many instances where dredges have worked the same ground several times, obtaining as good returns from the succeeding as from the first operation.

For effecting separation, various appliances are employed, usually in combination, such as (*a*) grizzlys, (*b*) trommels, (*c*) shaking tables, and (*d*) perforated plates.

(*a*) *Grizzlys.*—As an instance of the use of the grizzly or bar-screen, one of the bucket dredges of the Waipori Company, New Zealand,* may be quoted. In this case the material, after being dumped from the buckets into a hopper, passed into a sluice in which was placed a grizzly formed of bars 6 ft. long placed ¼ in. apart. Underneath this grizzly was a distributing-box, from which the fine wash was discharged for further treatment.

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* "Reports on the Mining Industry of New Zealand," 1893, p. 132.

One of the Sew Hoy Company's dredges also employed a similar method. The material was lifted by the buckets to 15 ft. above the water level, and then discharged on to an inclined grizzly made of flat iron bars 3 ins. by ¾ in., spaced 1¼ ins. apart. The fine material from the grizzly passed into sluices.

A grizzly, installed in one box of the main sluice of a dredge in Ophir Creek, Seward Peninsula, consisted of round iron rods, disposed longitudinally above the bottom of the box, the gold being saved on mats below. This box, at the end of a 120 ft. sluice, was said to save much fine gold.

Capt. Parker some years ago improved on the stationary grizzly by constructing what might be termed a travelling grizzly. This was employed with fair success on Parker's dredge, operating in the Greymouth district, West Coast, New Zealand. The difficulty of washing and sizing some 53 cubic yards, or 80 tons, of gravel per hour on a limited table area was to a great extent reduced by the use of this travelling grizzly, or table, which was 7 ft. 6 ins. long and 4 ft. wide; having the discharging end 9 ins. higher than the receiving end. The table itself was made of bars or plates 6 ins. wide, which were perforated with ⅜-in. holes. The plates were all hinged together so as to form a flat surface when conveying the material, and, being hinged, the table travelled round pulley-wheels at each end, and formed a complete chain belt. This apparatus was driven off the vertical shaft, on which the pinion was placed to drive the crown wheel on the tumbler shaft, and the speed of the table was about equal to that of the vertical shaft. The dredged material was lifted to a height of 24 ft. above water level and dumped into the hopper, which shot all the material on to the travelling table; a portion of the water from the centrifugal pump came into the hopper and then on to the travelling table, washing the dredged material and carrying all the fine sand through the perforations in the belt, while the coarse stuff, shingle, and stones, was carried away on the table, and, when it passed over the end pulley, the coarse material was shot into an inclined shoot into which a stream of water from the pump was brought to convey the waste material away clear of the dredger stern. The fine material fell on an inverted Λ slide, placed directly under the travelling belt, which caused about an equal quantity to fall into a longitudinal shoot on each side, and thence from this shoot the material and water was distributed on to the gold-saving tables. The stone and gravel shoot was made in semi-circular form of iron plates, and carried on light trestle-work, placed on a floating platform at the stern of the dredger. This platform was supported by a number of casks and barrels lashed together, and by this means the waste material was deposited about 120 ft. beyond the stern of the dredge. This floating platform was of primitive construction, and did not give full satisfaction; as, for instance, when a block took place in the stone shoot, the extra weight of material at this particular place sank the platform and consequently the shoot, and therefore the grade ceasing to be uniform became difficult to clear. Speaking of this appliance, the official report* says: "Although it is somewhat crude as regards the mechanism, Capt. Parker has given the right idea to separate the material, and no doubt many of the dredges in the future will be provided with a similar system of separating the sand from the coarse shingle and stones; but Capt. Parker's travelling table is not long enough to carry away the material over the stern of the dredge unless a shoot is used of considerable length, and this seems the most objectionable part of his appliance. The table should be long enough to convey the wash material over the stern of the dredge with a short shoot at the end on a steep incline, which would require no water to be used to carry any coarse material away clear of the dredge."

The author would, however, point out that the grizzly, whether stationary or travelling, has no active influence on the washing and separating of the material. To obtain this positive washing, disintegrating and sizing action, recourse must be had to some such machines as trommels.

(*b*) *Trommels.*—Trommels, or revolving screens, on account of their direct separating action, are largely employed, being placed either alone, or, more frequently, after the grizzly. The buckets occasionally empty direct into the trommel, but in most cases they should discharge first into a drop-shoot fitted with water jets and a steel bar grizzly.† The material so sized, propelled, if necessary, by a stream of water, is then delivered into the trommel or trommels. These are constructed occasionally of longitudinal iron bars, but more generally of ½-in. perforated boiler-plate. The size of the perforations depend on the class of gold to be saved. In some cases, they vary from $\frac{3}{10}$ in. diameter at the upper to $\frac{3}{8}$ in. at the lower end; in other cases they are between $\frac{5}{16}$ in. at the upper to ½ in. at the lower end. In North American deposits, where dredges have been installed, as in the Klondike and on the Stewart River, punched iron screens, used in revolving trommels, have large holes, up to 1½ ins., even when a tailings stacker is used, while the average size in Oreville is ⅜ in. In dealing with New Zealand gold-bearing marine deposits, $\frac{7}{16}$ in. holes appear sufficient. On the Birrim River, E. Akim, the 3¼ cu. ft. dredge of Pritchard's Dredging Co., screens with ⅜-in. holes. These are only instances of variations. In length, trommels are from 17 ft. to 30 ft., according to the amount of washing and separation the material requires; in diameter they are about 48 to 60 ins., and sometimes fitted with angle-iron worms. They are set with a slight inclination towards the discharge end, with just sufficient grade to enable the cylinder to clear itself, whilst thoroughly washing the contents. The cylinders themselves are supported on six or more friction rollers, and slowly rotated by spur or, preferably, by friction wheel gear. The washing and screening are assisted by continuous jets descending from a perforated water-pipe passing along the top of the screen inside, and driving the gold and fine sands through the perforations, while the rough wash and stones pass out to the elevator buckets. If the perforations become clogged, they can usually be sufficiently cleared by running clean water through and rotating the trommel in the opposite direction.

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* "Reports on the Mining Industry of New Zealand," 1892, p. 98.

† The direct dumping of the wash into the trommel will work satisfactorily for small-sized gravel, but with boulders of 100—150 lbs. it seriously increases the wear and tear of the screen.

In his "Notes on Gold Dredging," 1898, Mr. J. B. Jaquet thus describes the revolving trommel or screen on a modern dredge. The buckets discharge their contents into a shoot which leads into the upper end of the screen. Here a spray of water washes the fine material and gold, through the perforations, directly on to the tables arranged below, and the screenings (coarse material) are delivered by a shoot from the end of the screen into the buckets of the elevator, or, in the case of the older machines, directly into the river. The screens vary in length from 10 ft. to 22 ft., and in diameter from 3 ft. to 4 ft. 6 ins. They make about 10 revolutions per minute. The two screens upon the Molyneaux Hydraulic Company's dredge have angle-iron worms inside, so that all the material passing into them travels eight times the circumference of screen while under the influence of the water. In order to ensure a more even distribution of the fine sludge upon the tables, the perforations near the end of the screen are either of smaller size or are fewer in number than elsewhere. Water is supplied by means of a spray-pipe which enters the screen from behind.

The patent improved screen of Messrs. McCallum & Roberts, Dunedin, is made in hexagon or other polygonal form, or corrugated or oval. This variation from the usual form results in the material being more turned over and shaken, and thus more effectually washed. In the polygonal form, the plates are flat, and can therefore be made of any thickness—*e.g.*, thicker in the centre where the chief wear takes place. Moreover, they can be made of manganese steel with the holes cast in. (*See* illustration.)

(*c*) *Shaking Tables.*—Mr. Gore, of Dunedin, one of the directors of the Sew Hoy Company, Shotover,* designed a shaking table to

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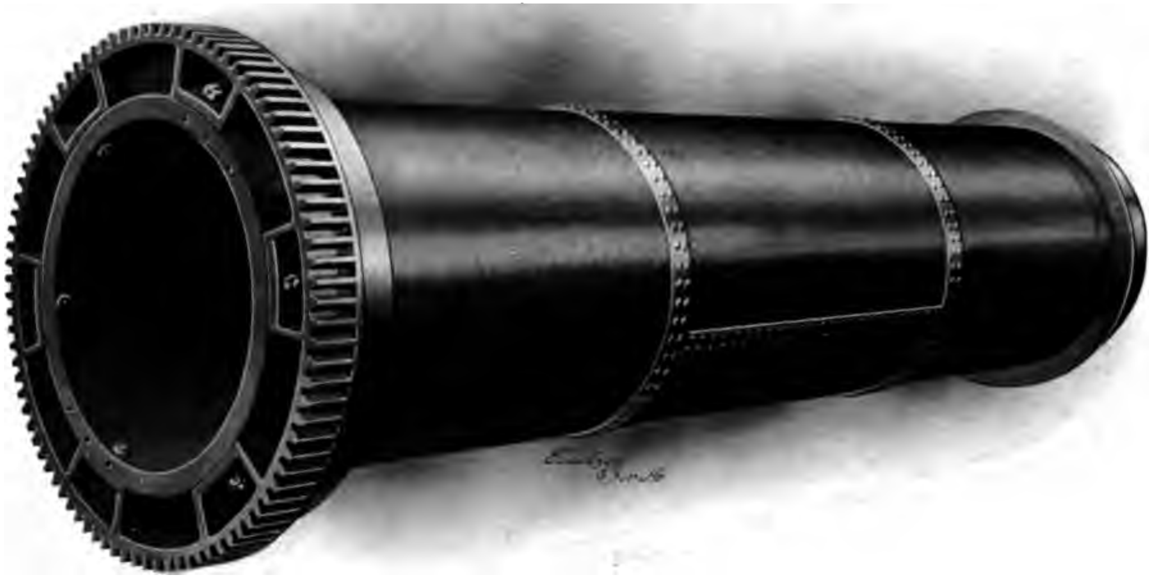
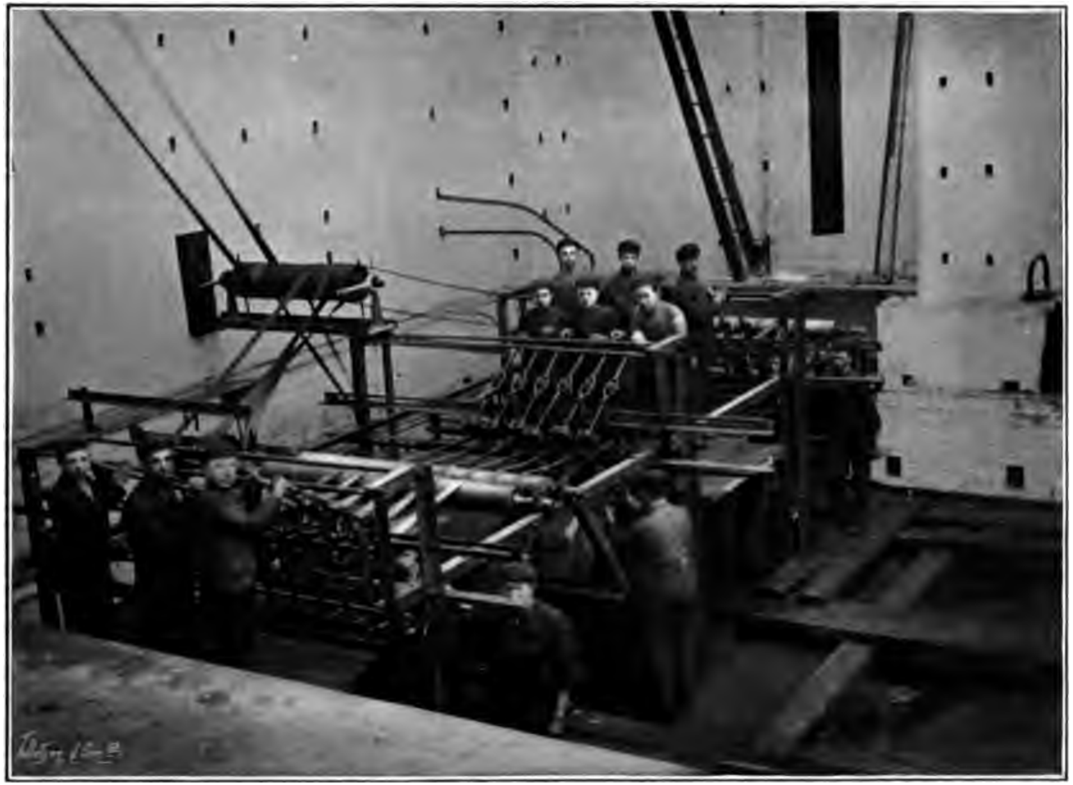
* "Reports on the Mining Industry of New Zealand," 1893, p. 132.



Trommel or Revolving Screen, as supplied by Messrs. Lobnitz & Company, Limited.



Multiple Drilling Machines for boring the holes tapered in Revolving Screens.—Designed and manufactured by Messrs. Lobnitz & Company, Limited.

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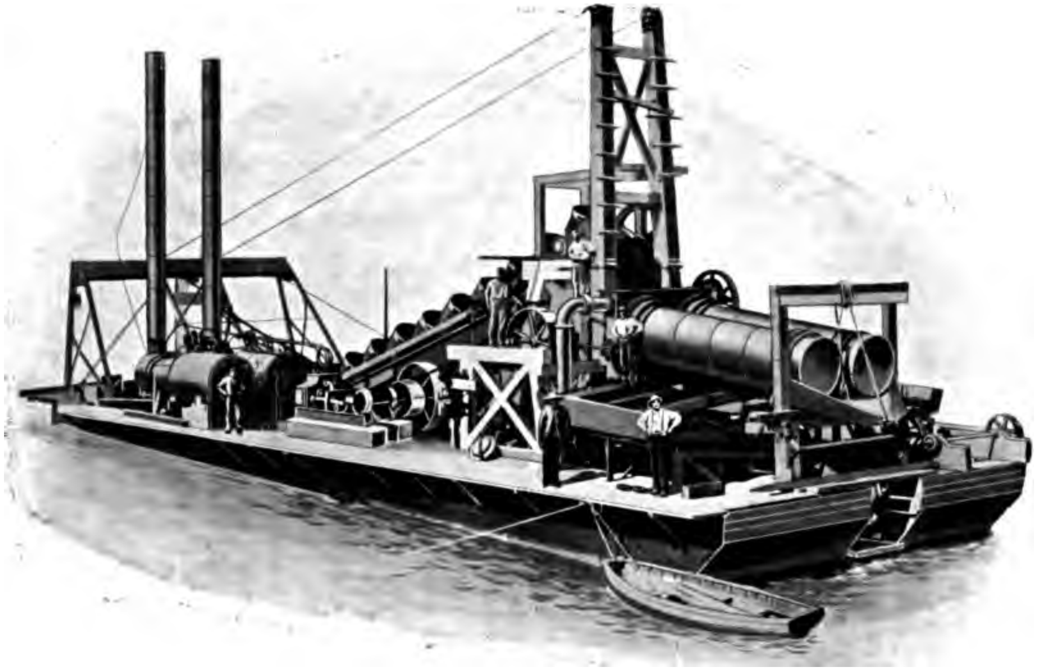
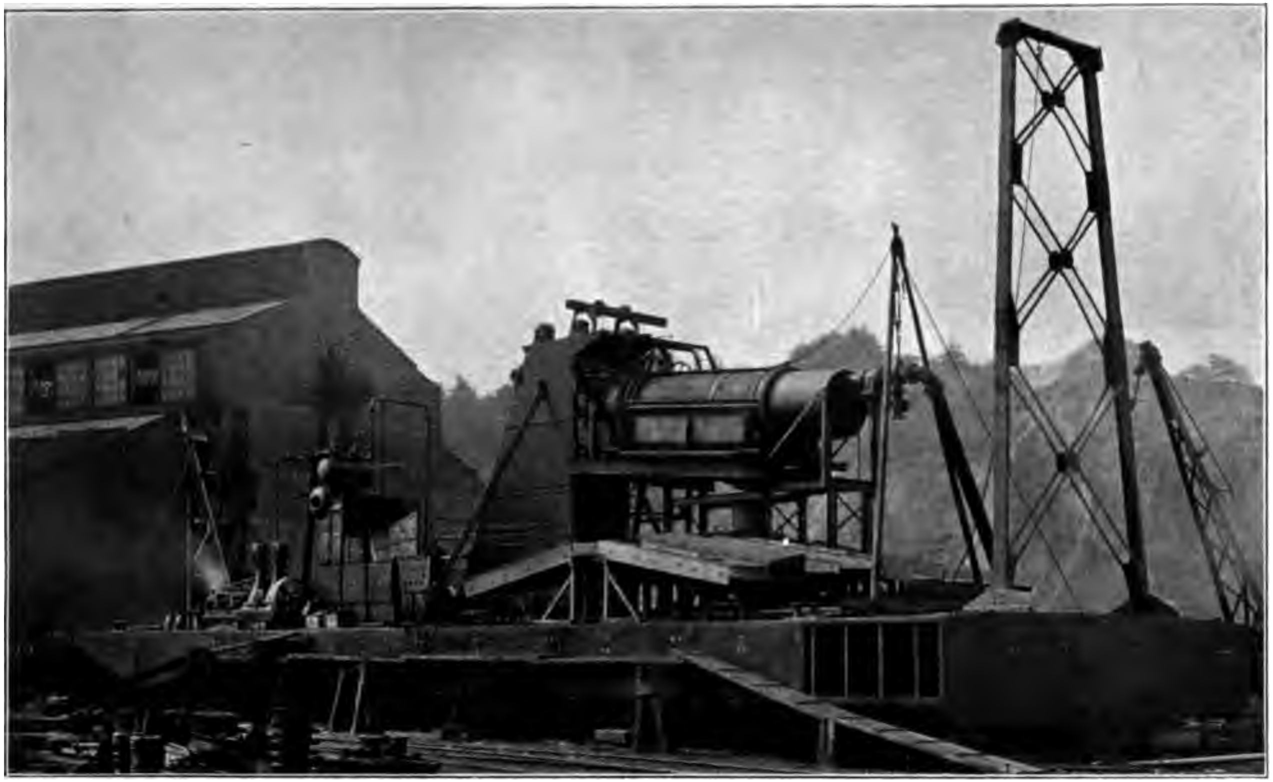
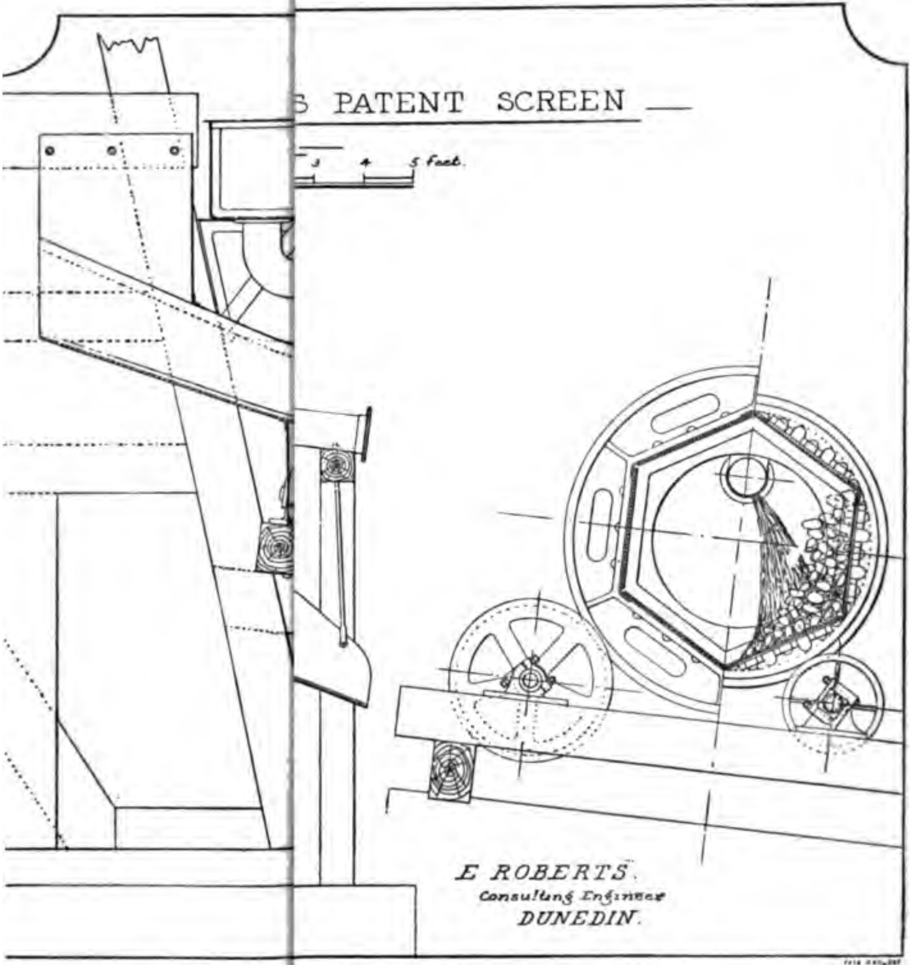


A Dredger constructed by Messrs. MARSHALL, SONS, & COMPANY, LIMITED, showing Trommels in position.



Gold Dredger under construction, by Messrs. **Fraser & Chalmers, Limited**, showing Trommel and Water-spray Pipe, &c., also Gold-saving Tables.

C3



…S PATENT SCREEN

E. ROBERTS.
Consulting Engineer
DUNEDIN.

separate the stones and shingle from the sand. It was said to work very well, but the wear and tear was considerable, and its use was discontinued. The Yale Dredging Company's dredge* was fitted with a grizzly 22 ft. long, placed 6 ins. above the bottom of a sluice, which was 4 ft. wide, and had a grade of 1 in 12. No effort was made to save anything in this sluice, the object being simply screening. The gravel was discharged by the sluice on to a shaking screen 5 ft. wide by 30 ft. long, made in two sections, where the screening was finished. The shaking screen delivered the gravel free from sand and water to the stacker or tailings elevator. Under the shaking screen was the sand-box and between them a distributor which distributed the sand equally throughout the length of each of the four compartments of the box. From the sand-box the sand and water were drawn off directly on to the burlap sluices arranged in two banks on each side. There were eight of these sluices in each lower bank and seven in the upper, making 30 in all, with a total area of about 1,300 square feet. One of each lower bank was thus always exposed, and by changing the position of the upper sluices one at a time the lower sluices were exposed one after the other for cleaning up. The uniform distribution of sand and water and nice adjustment of grade of the sluices are essential to a close saving. The distribution is obtained by the arrangement described, and the sluices are provided with means for quickly changing the grade so as to adapt them to the varying proportion of sand contained in the gravel handled from day to day. The dredge was 90 ft. in length and 30 ft. wide, and had a nominal capacity of 180 cubic yards per hour. It is not improbable that shaking tables may largely co-operate with, if not supersede, revolving screens, owing to their greater screening area actually in operation. As Mr. C. E. Turner observes: "In proportion to the amount and weight of matter in motion, the screening area of the revolving screen is very small. When there are 16 feet of perforations in a 5-ft. diameter screen, there might be 28 square feet actually screening, whereas a shaking table screen of similar length and only 30 ins. wide would give 40 square feet screening, beside depositing the fine gravel more evenly over the matting on the screen-table. Much of the fine gold is not able to reach the matting after leaving the revolving screen because the fines are deposited all on one side of the table."†

(*d*) *Perforated Plates.*—Iron or steel plates, punched or slotted, are largely employed for separating fine from medium-sized material. They are chiefly set in the sluice-boxes over matting or plush, and their use will be described in the examples subsequently given.

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* "Mining & Engineering Journal," New York, October 6, 1900.

† "Gold Dredging in New Zealand," "Mining Journal," December 6, 1902.

IX.—Gold Recovery Appliances.

THE coarse material having been separated from the fine by the means above described, the next step is to recover the gold from the latter. Gold recovery appliances for alluvial material have been fully discussed by the author in "Hydraulic Mining," Part III.,[*] and it may be briefly stated that the same appliances, on a more limited scale, are used in dredging—namely, catch-alls, sluices, riffles, gold-saving tables, amalgamated plates, &c. Applied to dredges, however, sluices and tables labour under two disadvantages. The limited size of the pontoons or barges that carry the dredging machinery restricts the space available for sluice and table area; and their unsteadiness in work tends to prevent gold-saving tables being used with maximum efficiency, the vibration from the machinery, together with the motion of the stream, not permitting the silt to run uniformly and evenly over the tables. As a preventive to rolling, the hulls of dredges carrying gold-saving appliances should be built with ample beam, so that the oscillatory movement is minimised.

As the percentage of gold saved depends chiefly on the perfection of the recovery arrangements, it becomes a question whether, in view of the limited surface area of a dredge, it might not be better to carry the whole of the washing and recovery mechanism on board separate pontoons,[†] or else to erect these appliances on shore, and pipe the dredged material to them.[‡] There are objections to both plans. In the first case, it is no easy matter to arrange alongside floating structures with sufficiently large area for the purpose; and it is difficult to keep them also free from oscillation, which, disturbing the transverse level of the tables, destroys one of the most important conditions for their efficiency as gold-savers. In the other case, the progress of the dredge would necessitate frequent alterations in the length of the delivery pipe, or a fresh arrangement of the sluices and tables, even supposing these were constructed on movable platforms.

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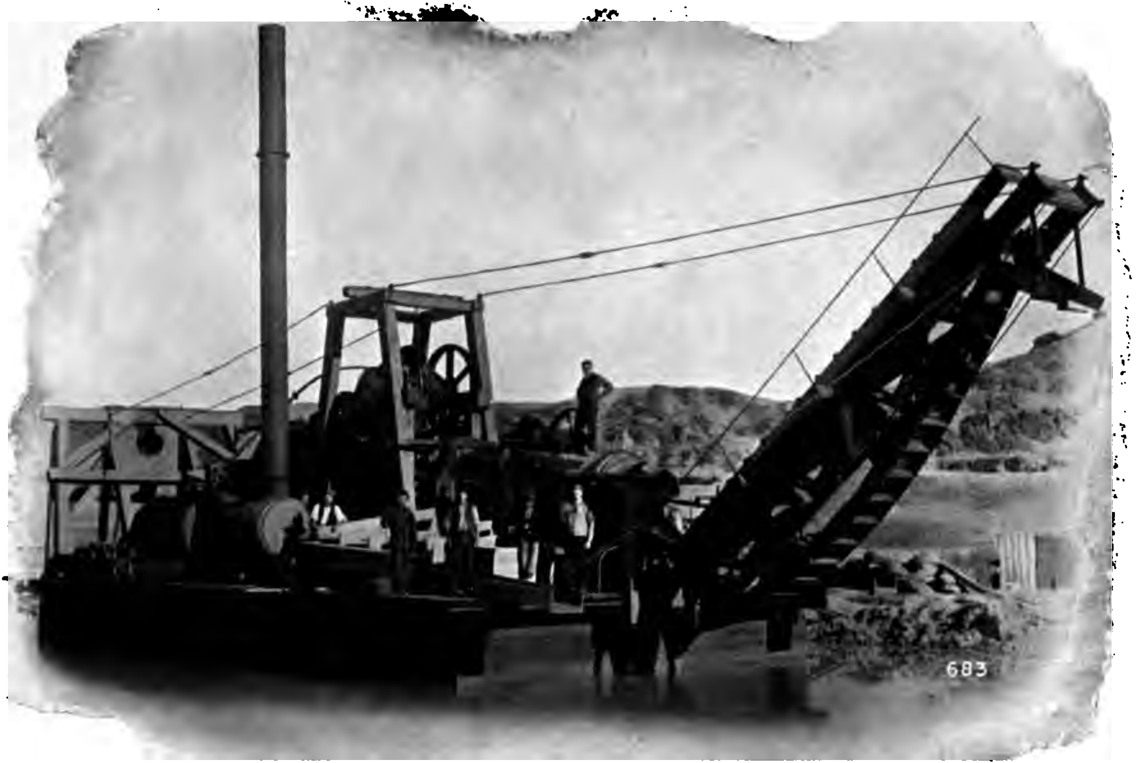
[*] "Hydraulic Mining," by Captain C. C. Longridge, 1899. Published by "The Mining Journal," London.

[†] The Pacific Gold Dredging Company, Idaho, carried their main gold-saving sluice on a scow trailed behind the dredge. The sands were conveyed across by a flexible rubber joint. ("Mines and Minerals," March 1899.)

[‡] In his report to the Under-Secretary for Mines, Wellington, Mr. Macfarlane writes: "In dealing with our beaches, largely composed as they are of grey and black sand, a stable foundation for the tables is an absolute necessity, with a spread of table, say, 120 ft., in cross section to deal with fifty tons per hour. This can never be obtained on a moving dredge."



Gold Dredger, built by Messrs. Marshall, Sons, & Company, Limited, Gainsborough, England.
Showing Trommel, Gold-saving Tables, Sluice, and Tailings Elevator.

In treating of hydraulic mining, the author has fully explained gold-saving appliances, and will, therefore, here proceed to illustrate their use by describing the arrangements on various dredges, from which the diversity of practice will be seen.

(*a*) *Catch or Save-all.*—The save-all is placed below the upper tumbler, and its purpose is to catch and treat the wash which, in falling from the buckets, escapes the hopper or shoot leading to the trommel. It consists of a short sluice-box or table, covered with matting, and protected from large stones by a grizzly, or by iron bars laid on the matting. A jet of water may be used to wash the coarse stuff into the well or overboard. In the Eureka dredge* the save-all was ingeniously slung on chains in order to shift it fore and aft to suit the angle of the ladder. Besides this spill loss, there is always more or less material adhering to the inside of the buckets, and where the gold is very fine the particles have a tendency to adhere to the sides and corners of the buckets, even when they appear to dump clean. To recover this loss, the Yale Dredging Company's dredge † was fitted with a small auxiliary pump, which threw two jets of water up into the inverted buckets as they descended, and all materials thus washed out, as well as the spill before mentioned, fell on an inclined screen at the rear end of the ladder-way. The fine portion dropped into the well immediately below, from which the large pump drew its water. All this valuable material otherwise lost is raised by the centrifugal pump and delivered into the sluices.

(*b*) *Sluices.*—As will be seen from the following instances, sluices are single or multiple, of uniform or varying dimension, with or without drops, and variously fitted with perforated plates, wire netting, expanded metal, linings, and riffles, according to the nature of the material or the preference of the builder. In the Sew Hoy Company's dredge on the Shotover,‡ the wash dirt, after being sized through a grizzly, fell into a sluice-box, which was 3 ft. wide and 48 ft. long, set on an inclination of about one in eight. From the end of and below this sluice ran a return sluice on a grade of one in twelve. The upper, as also the lower or return sluice-box, was made of plate iron, the bottom being covered with calico, on the top of which was stretched cocoa-nut matting. In the upper sluice-box there came, first, 12 ft. with iron riffles, then 12 ft. with slips of wood 1 in. deep laid along each side of the box and supporting perforated iron plates, having holes $\frac{3}{16}$ in. in diameter, permitting only fine silt to fall through on to the matting. Below the plates was another 12 ft. with iron riffles, and the final 12 ft. was covered, as before, with perforated plates. But the fine material that passed through this last set of plates fell into the return sluice-box, which was covered with iron plates, perforated with holes ⅛ in. in diameter, resting, as before, on wood slips laid over matting. The material from this lower or return sluice passed into a small tank, and was deposited overboard directly at the stern of the dredge.

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* "Reports on the Mining Industry of New Zealand," 1895, p. 154.

† "Mining & Engineering Journal," New York, October 6, 1900.

‡ *Ibid.*, 1890, p. 90.

The dredge belonging to J. Nelson & Co., working at Glenore, Otago,* was fitted with three parallel sluices, each 3 ft. wide, with a fall of 18 ins. in 12 ft. The buckets discharged into the centre sluice. The material first passed over 6 ft. with riffles, and then alternately over perforated plates and riffles to the end of the box. The fine sands, passing through the perforated plates, flowed through gauged side apertures into the sluice on either side. These latter were lined with matting only. Most of the gold, though very fine, was found in the first 12 ft. of the centre sluice. Mr. J. Nelson, the manager, was of opinion that a less fall to the sluice-box would probably suit better, were it not for the many large stones, which had to be assisted down the box to where they could be lifted out by hand and rolled overboard. Of course, more water could have been put through to carry the stones to the end of the sluice, but this might have resulted in a loss of some fine gold now being saved. There was a considerable amount of clay all through the stuff dredged, and much of it passed out in lump at the tail of the sluice-box, and, no doubt, carried gold with it. There can be little doubt that this arrangement would have been benefited by better preliminary separation, and by puddling the lumps of clay.

The sluice-boxes of the Golden Run dredge, on the Clutha,† were given a fall of 1 in 8, and were fitted with perforated plates having ¼-in. holes 1 in. apart. Under the plates was plush, covered for a length of 20 ft. with fine wire netting of ½-in. mesh. Following the plates, came 8 ft. of sluice with angle-iron riffles, set on the plush. After this there were 12 ft. of perforated plates, with cocoanut matting beneath. The rest of the sluice was lined, along the bottom with calico. Notwithstanding all these precautions, some fine gold was still found at the tail end of the sluice.

On the Waimumu Queen Company's dredge,‡ Mr. Quertier designed a novel arrangement of sluice-boxes. For 18 ft. from the buckets, the box is 6 ft. wide, and, for the remaining 36 ft., it is narrowed to 3 ft. Where the diminution of width takes place, the box is shaped like the neck of a bottle, the shoulders thus caused centralising the force of water, and tending always to the effectual breaking-up of large masses of clay. For the full length of the main sluice, the perforated plates, set from 4 to 6 ins. over the matting, are laid like steps, each step being about 5 ft. long, in such a way that the final wash falls through the perforations on to the matting below, and emerges again on top of the plate next lower down. The material is thus passed over the plates and matting alternately all the way down, this arrangement tending to reduce the loss of fine gold to a minimum.

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* "Reports on the Mining Industry of New Zealand," 1895, p. 151.

† "Reports on the Mining Industry of New Zealand," 1895, p. 152.

‡ "New Zealand Mines Record," July 16, 1900.

The next example shows the use of "drops."

In the Eureka dredge,* the wash-dirt was passed through a revolving screen, 6 ft. long and 3 ft. 3 ins. in diameter. The first box under this cylinder stood at right angles to it, and was 6 ft. long by 3 ft. wide; there was a 6-in. drop into the next box, which was 8 ft. long by 3 ft. wide; this, again, had a 3-in. drop into another box, 8 ft. long by 3 ft. wide. This last box carried perforated plates and matting covered with wire netting. The bottom of all the boxes had cocoanut matting. These boxes saved a fair proportion of the gold obtained when working in sticky clay and sandy bottoms.

A novel arrangement of riffles was found in the Sandhills electric dredge.† The wash-dirt was discharged from the buckets into a short shoot overlaid with heavy steel plates; thence it dropped into the head of the main shoot or dummy. The head of this shoot was 16 ft. long by 3 ft. 6 ins. wide, the remainder being 40 ft. long and 2 ft. wide. The riffles were made of steel tram rails; they were of various shapes, and arranged in different positions in the shoots. The portions used in the dummy, bent or curved at the angles, were found to be most suitable. Owing to the rough nature of the gold, the spaces between each riffle ranged from 1 in. to 2 ins. The riffles were so curved as to cause the wash-dirt to spread evenly over the whole width of the shoot, thus insuring thorough washing before discharge. These riffles were laid on strips of wood 1 in. thick, and set in opposite directions to them, and under them was matting. The set and section of the bars made the riffles an excellent catch for coarse or fine gold. It is stated, as an important feature in the working of these ripples, that they did not fill and become hard. They were easily made, handled, laid, and lifted, and were very durable.

The question whether sluices alone are sufficient means to save gold in the usual material dredged from beaches, flats, and river beds, the author answers in the negative. Undoubtedly, properly equipped sluices save a certain proportion and a certain class of gold, but they do not recover the finest particles. It is said that in the case of the Golden Run dredge, on the Clutha, the eye could easily detect a difference in three isolated samples of gold, arrested by each kind of riffle. But it requires no such test to establish the distinction between gold sufficiently coarse and heavy to be arrested in sluices carrying a full current, and that so fine and minute as to be lost, unless the entire stream filters, as it were, through an arresting medium. It is no valid argument to retort that in the sluice-boxes very little gold is found below the first strips of plush or matting, and that the bottom strips, when washed, yield scarcely any return. Such reasoning rests on the false assumption that the whole of the gold is capable of being caught in a sluice, and ignores the fact that, of the total quantity present, a portion only can be so recovered, while the rest is of such a nature as to defy the action of the sluice. Those familiar with hydraulic mining will admit the necessity of undercurrents for successfully dealing with a certain class of alluvial gold; and, bearing this in mind, will recognise that silt containing gold of a similar description must require an apparatus of a like nature. In other words, the finest particles of gold in wash-drift can be saved only by being carefully passed over a wide area, under the action of a nicely-adjusted and uniform supply of water. This is the function of—

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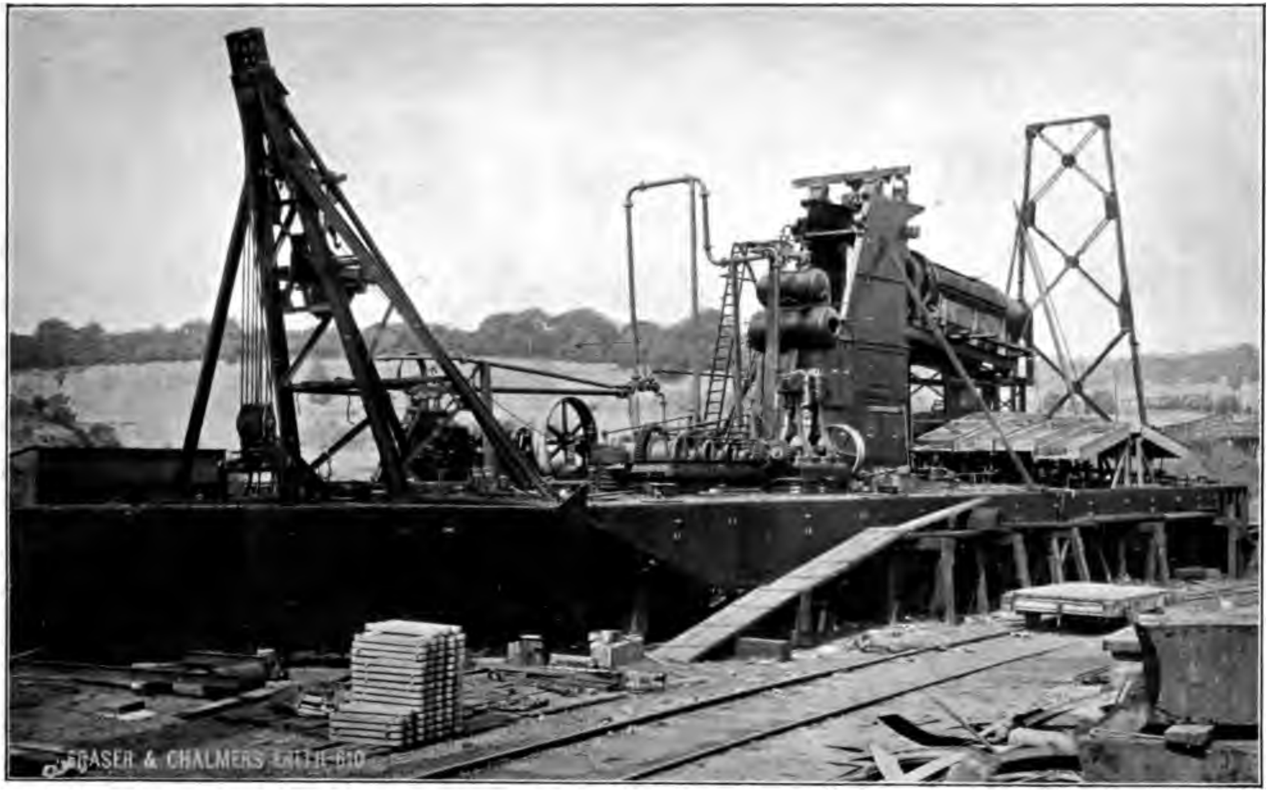
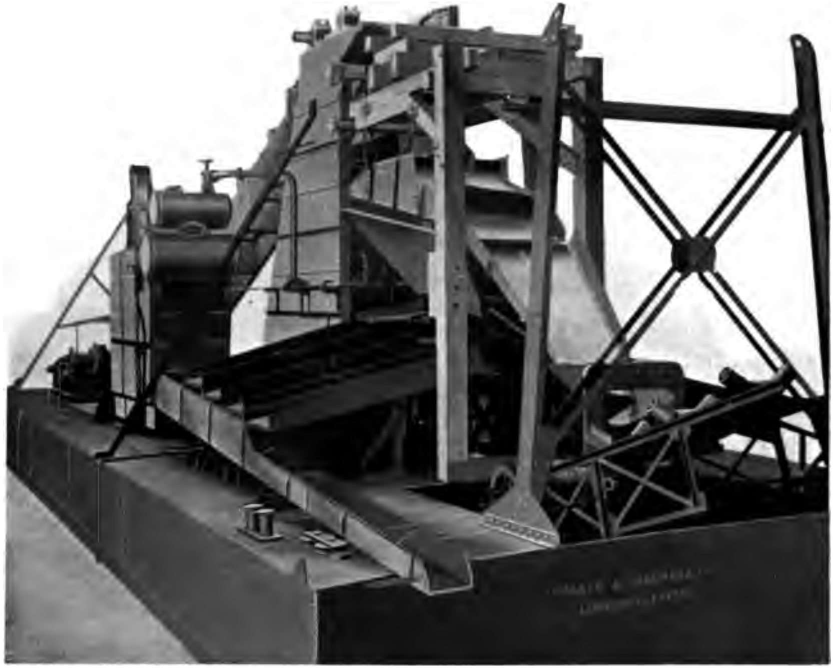
* *Ibid.*, p. 154.

† "Reports on the Mining Industry of New Zealand," 1897, p. 139.

(*c*) *Gold-saving Tables.*—These appliances consist of wide inclined streaks or tables, covered with matting, baize, plush, or suitable material, over which the material flows in a thin film. This film must be so thin that every particle of solid matter rolls down in contact with the surface of the material used to arrest the gold, and is not simply held in suspension, floated over the covering, and finally lost. Before a dredge, therefore, can be successful in working ocean beaches and river beds, so as to save the maximum, or, in many cases, even a fair percentage of the fine gold, there must be an adequate installation of gold-saving tables. These are sometimes made of cast iron, sometimes of sheet iron or steel plate, 10-gauge thick, set parallel and secured together, the one stepped below the other to correspond with the fall or pitch of the trommel. Each set of tables or boxes has a fall from the centre towards the sides of the dredge, where, in the case of single tables, they discharge into the tail shoots, delivering the fine dirt behind the stern or to an elevator. The tables, placed in sets either on one or both sides of the trommel, are divided into three, four, six, or eight sections by longitudinal strips, and so arranged that any one section can be cut out and washed without interfering with the others. In some instances, the fines from the trommel drop directly on to the tables below, which in that case have a total width equal to the working length of the trommel. In other instances, the gold and fines are



Gold Dredger under Construction by Messrs. Fraser & Chalmers, Limited.
Showing Gold-saving Tables, below the Trommel, &c.



The Turner Patent Gold-saving Tables.
(Sole Manufacturers, Messrs. FRASER & CHALMERS, LIMITED.)

first caught in a distributing box, from which, through adjustable doors, they flow in a thin and constant stream over the tables. To increase the total area, the tables may be duplicated, &c., by placing other sets, sloping in the opposite direction, below the top ones. The length of the tables is generally about 16 to 18 ft.

There are, of course, a number of patented tables. Some of these are of well-known and approved design. Those of the Risdon Ironworks are constructed of cast iron planed on the edges, so that they are interchangeable, and fitted with double eccentric cams, which form a ready means of holding down the cocoanut matting and expanded metal with which the tables are covered. Half way down the tables there is a drop into a trough, so as to catch any round nuggets which might otherwise roll over the tables.

The makers state: "It is found by actual experience that all the fine gold is caught in the first 9 ins. of the top of the tables. We have samples of gold saved on these tables which are practically impalpable, being so fine that it goes through the chamois leather after amalgamation. While we do not claim to save 100 per cent. of the gold values in the ground, we do claim that constant and persistent panning of our tailings will only very occasionally show a colour, and we believe that we save practically all the values on the ground. After leaving the tables the material passes over a sluice covered with our patent angle iron riffles. In the case of a dredge, the principal use of these is to form a cheap sluice bottom for the material to pass over at the same time. If by any carelessness the tables are allowed to clog, the riffles catch any gold which might pass over them."

Messrs. Fraser & Chalmers, Limited, recommend their Turner gold-saving table, claiming as some of its advantages: (1) Accessibility; (2) large area; (3) equal distribution of material which can be varied at will; (4) clean-up can be carried on without stopping the dredge; (5) the tables are locked so that gold cannot be stolen; (6) inclination of the separate tables can be varied as desired; (7) increased saving of gold; (8) sections of tables are all interchangeable. They believe that in many cases the installation of these tables would greatly increase the returns, and certainly pay for themselves in a very short time.

In the use of the table it is very necessary that no more water should be used than is needed to keep the surface clear. As soon as sand appears on the table, it is certain that little or none of the fine scaly gold is being saved. In the ordinary dredge this is difficult to arrange, because the discharge from the buckets is not constant. Sometimes they come up full, and at other times not so. This affects the quantity of water required. It is, in any case, better to have plenty than insufficient water, as, in the latter event, sand will accumulate on the table and insure a loss of gold; while, in the other case, if once the gold gets down on the matting, the water will seldom lift it. Another difficulty in table management lies in the fact that the pontoons or barges which carry the dredging machinery are not sufficiently large for sufficient table area, nor sufficiently steady for fine gold-saving tables to be efficiently used. The vibration from the machinery, as already remarked, together with the oscillation in the stream, alters the grade and level of the tables, and does not permit the material to run uniformly and evenly over them.

To arrest the gold on the tables various coverings are in use, such as calico, cocoanut matting, plush, baize, &c. Calico is used to catch any fine gold that may pass through the matting, &c. For convenience in washing, the mats, &c., are in lengths of 3 or 4 ft. Sometimes they are held down by coarse iron netting, or, preferably, expanded metal,* and longitudinal iron riffles; in other cases, by strips of wood laid along the edges and wedged by wooden wedges or clips, along the side-divisions of the tables.

The choice of material for covering the tables is largely a matter of experience and expense. Cocoanut matting within certain limits, answers admirably. Owing to its porous character, it is usually supplemented by linen placed beneath. On some dredges, plush is used. At Island Block it was found that the plush used in the side runs caught too much of the black iron sand, and got quickly choked. At Waipapa, with a very large proportion of fine black sand, it answered well. The difference of experience was probably due to the quantity of water used, and to the grade of the table. These two latter points are matters for experiment in each case. Where the presence of much black sand is found to choke the tables, the first few divisions of these might, perhaps, be made in the form of travelling endless belts, working over rollers, the face of the mat being continuously cleaned by brush or water jet, as it travelled back under the rollers.

Mr. Jaquet, in his "Notes on Gold Dredging,"† thus describes the usual arrangement and size of gold-saving tables: "The tables for catching the gold are, upon most dredges, arranged in three shelves, so that the centre of each table is equi-distant below the screen. They have, in the aggregate, a width equal to the length of the screen, and a length from 10 ft. to 14 ft., and a fall of 1½ ins. to 1¾ ins. to the foot."

Mr. C. E. Edwards, writing on New Zealand practice,‡ says: "The system of gold saving obtaining is a system of tables set at

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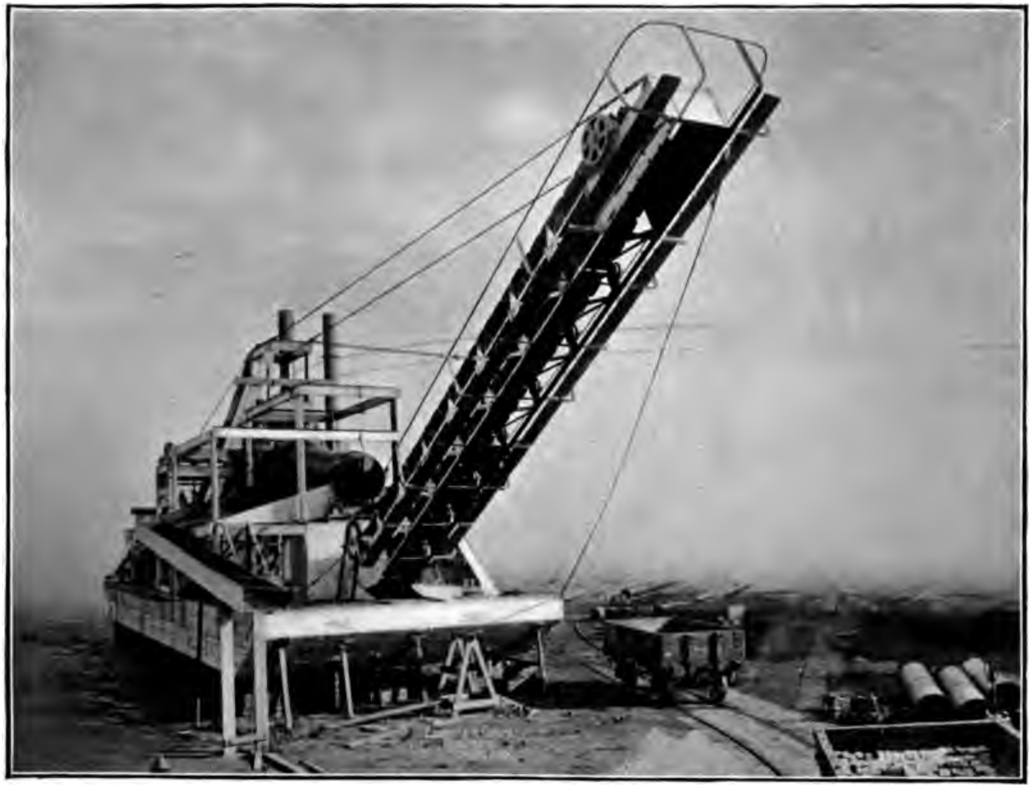
* As a means of arresting gold by creating a ripple, and of protecting deposited gold, wire netting and expanded metal have come largely into use.

† Page 12.

‡ "Gold Dredging in New Zealand." "Mining Journal," December 13, 1902.



Gold Dredger, built by Messrs. Lobnitz & Company, Limited, Renfrew, Scotland.
Showing Trommel, Gold-saving Tables, Sluice, and Tailings Elevator.

various pitches between the limits of 1 in. to 2¼ ins. to 1 ft., and covered with calico, under cocoanut matting, or baize, or plush; and these again are protected by expanded metal wire netting, chains, and various other devices. With heavy, shotty gold the tables are often narrow—24 ins., or less—and with the maximum pitch. This gives a minimum of space for a maximum of wash treated. But the practice is reprehensible, as fine light gold often accompanies the heavier sample, and must necessarily be carried overboard. In the best observed practice, the tables were so pitched that the particles of heavy black sand accompanying the gold were just kept moving in as small depth of water as would carry away the fine gravel of the wash. Practice has shown that a long uninterrupted flow is not the best kind of table for saving fine gold, but that a 20-in. or 24-in. run, then a turnover, then another run and turnover, and so on, giving three or four turnovers to each length of table, gives better results. The spread of tables is regulated by the proportion of fine to coarse wash. The depth of water on the tables should not exceed the diameter of the largest perforations in the screen, and the pitch should be regulated so there shall not be too much velocity, but just sufficient to keep the pulp alive. The practice of driving the pump and gold-saving apparatus from the main engine does not recommend itself to all. The fluctuations caused by the buckets getting hold prevent the same conditions being maintained, therefore best results cannot be expected. Two motors would seem to recommend themselves, one for the pump screen and elevator and the other for the buckets and winches."

This description may be supplemented by several examples taken from dredges employed in New Zealand. The first of these is the Welman Suction Dredge on Waipapa Creek,* lifting 35 tons of solid matter per hour, of which 95 per cent. is sand and fine shingle. In this machine, the fine material passed on to a distributing board, which was 12 ft. wide and 6 ft. long; and from this the water and material flowed on to the gold-saving tables. These tables were 2 ft. wide and 30 ft. long, six of them being on each side of the dredge, so that there were 720 square ft. of surface in the gold-saving boxes or tables. The tables were longitudinal with the dredge, had a fall of about ¾ in. to 1 ft., and were covered with plush for about 18 ft. to 20 ft. in length from the discharging hopper towards the stern; but on the bottom end there was neither plush, blankets, nor riffles for saving the gold, so that the whole of the gold was collected on not more than 480 square feet of surface. From the end of the longitudinal tables, the water and material dropped into a sluice-box running at right angles to the tables, and delivering all the water and waste material on to the ocean beach, where it was distributed by the waves. The stones accumulating on the hopper-plates were raked overboard.

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* "Reports on the Mining Industry of New Zealand," 1890, p. 89

On Parker's dredge, Greymouth District,* there were six tables on each side of the stem end of the tumbler shaft, each 14 ft. long by 4 ft. wide, and five tables on each side of the bow end of the tumbler shaft, 11 ft. long. The latter, however, were not used, as it was found difficult to get the fine material evenly distributed over them. The area of the tables used was 672 square feet to deal with 53 cubic yards, or 80 tons per hour.

The table arrangements on the Waipori dredges were as follows:—†

The dredged material was lifted 16 ft. above the deck, and dumped into a hopper, which led into a revolving screen, having longitudinal bars 2 ins. wide and ⅜ in. apart. The coarse material was delivered into a sluice 32 ft. long by 3 ft. wide, with a fall of 15 ins. in 12 ft., fitted with iron riffles. The fine stuff fell into a box, which distributed the material on to tables set at right angles to the revolving screen, and covered with matting. There were five tables at each side, each 2 ft. 6 ins. wide and 10 ft. long. These tables emptied into another longitudinal sluice, fitted with iron riffles, the sluice being 36 ft. long and 3 ft. wide, with a fall of 12 ins. in 12 ft. The average quantity of material lifted was 46 cubic yards per hour, and the surface area of the tables to save the gold was 250 square feet. This may seem a tolerably large surface area of tables, but the length of tables has not nearly so much to do with saving gold as their width; thus, for instance, a table 6 ft. wide and 42 ft. long would have a surface area of 252 square feet, but, as the whole of the material would have to be confined to a width of 6 ft., the material would have to pass over in seven times as thick a film as it would do were the tables 42 ft. wide and 6 ft. long, and, therefore, far more gold would be got by the tables being wider. In order to distribute the material evenly over the tables, there was a longitudinal box placed beneath the revolving screen, which was 12 ft. long by 3 ft. to 3 ft. 6 ins. in diameter, with ⅜ in. perforated holes. To get all the material from the screen to fall into the centre of this box, use was made of a sheet-iron plate, bent into the segment of a circle, and placed on the side of the screen against its revolving motion. As most of the material came out of the screen on this side, the segment plate shot it down to the centre of the distributing box, and by this means it was evenly distributed over the tables on both sides of the screen.

In the Matura dredge,‡ handling 30 tons per hour, there were five tables, 2 ft. wide and 21 ft. long, set on a grade of 1 in 12. This gave 210 square feet of washing surface, which is insufficient for the amount of material.

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* "Reports on the Mining Industry of New Zealand," 1892, p. 98.

† *Ibid.*, 1893, p. 129.

‡ "Reports on the Mining Industry of New Zealand," 1890, p. 90.

The Sandhills dredge,* lifting 30 tons per hour, had a total table surface of 144 square feet, which also is insufficient for proper recovery.

In the Manuherikia dredge,† Clutha, the fine material was treated on tables 6 ft. wide, covered with matting, and was then passed into a box sluice 14 ft. long and 3 ft. wide, covered with matting and wire netting.

The gold-saving tables on the Clyde dredge,‡ Clutha, were 10 ft. wide by 12 ft. long, covered with matting and wire netting. There were also 36 ft. of sluice boxes, 2½ ft. wide, with perforated plates and matting. But nearly all the gold was saved on the wide tables.

The Gold Queen dredges§ at Roxburgh had a 20-ft. trommel, with a working surface of 12 ft., and the tables, 12 ft. by 3 ft., were subdivided into eight sections, four on either side of the trommel. Under these were duplicate tables of similar size and number, giving altogether a gold-saving spread of some 500 square feet. The return tables were provided with a separate shoot, which carried off the finer tailings.

It is unnecessary to insist again that the width of gold-saving tables and the consequent thinness of the flowing film is a far more important factor than length.

A difficult material for tables to deal with is black sand. "The gold found in the littoral deposits (West Coast), both recent and alluvial, is in a free state of division, and, as it occurs with large quantities of magnetite, ilmenite, garnet, and other minerals of high specific gravity, has long exercised the ingenuity of miners and others to obtain a fair extraction, when dealt with in quantities. The effect has been a tendency, not only to extend the spread of the tables, but also to provide distributors and mixing boxes, so that the pulps passing over each foot in width of the tables shall consist approximately of definite proportions of mineral matter and water. The latest improvements are embodied in Cowan's Pactolus tables and Phillips' black-sand tables. The tables are superimposed one over the other, thus increasing the table area. The upper spread of tables is fed from one side of the distributing-box, and the lower from the other side, the distribution being regulated by doors. The sand is saved with the gold, and afterwards separated by amalgamation. If any loss occurs, it is due to the failure of the centrifugal pump to lift the required quantity of water, when the engine is slowed down by overload."*

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* *Ibid.*, 1890, p. 90.

† *Ibid.*, 1895, p. 154.

‡ *Ibid.*, 1895, p. 155.

§ "New Zealand Mines Record," July 16, 1900.

On the treatment of such sands, Mr. G. J. A. Richardson, of Invercargill (New Zealand, "Minerals & Mines," 1902, p. 26), writes: "From personal experience I am satisfied that on beach claims, composed of heavy black and grey sands, it is impossible to deal with more than from 25 to 30 tons per hour, and save anything like a fair percentage of gold. One dredge under my charge on a beach claim was capable of lifting from 80 to 100 tons per hour, the superficial area of the saving-tables being 432 ft., water-supply eight Government heads; not more than 20 to 25 tons per hour could be put through with advantage, and from this quantity from 60 ozs. to 80 ozs. of gold per week was obtained; every attempt to increase the quantity lifted only resulted in blocking the tables and consequent loss of gold. If satisfactory results are to be obtained, the following questions should have the attention of all concerned in gold-dredging, more especially when fine gold is present: (*a*) Area and position of tables; (*b*) quantity of water and even supply; (*c*) even distribution of spoil and water over tables; (*d*) size of runs or boxes; (*e*) lifting separate runs without stopping dredge; (*f*) constant attention to tables. (*a*) After repeated experiments I found, in dealing with fine gold and black sand, that a wide spread of boxes is absolutely necessary, so that the spoil may be distributed over a wide space of saving surface, and, to this end, room must be provided on the dredge-punt on which to erect the boxes. The boxes should run fore and aft of the dredge, not athwartship. (*b*) The quantity of water should be such as to allow of a constant run of a ¾-in. pipe over the whole surface of the tables, the tables having a fall of 9 ins. to the 12 ft., and a break and a direct drop of 1½ ins. every 6 ft. (*c*.) The matter and water should be evenly distributed over the whole width of the boxes by means of a spreading-table, and the velocity of the water checked before reaching the tables by falling from the spreading-table on to the return run. The pump should never be run from the shaft of the main engine, for the reason that, when buckets are lifting to their full capacity, the engine slows down, and the water-supply is reduced, whereas when the buckets are but partially full the speed of the pump is increased; thus the water-supply is reduced when it should be increased, and increased when it should be reduced. The pump, therefore, should be run from an auxiliary engine apart from the main engine. (*d*.) The usual breadth of a run is 3 ft., but for fine gold plush should be used, and 2 ft. width gives the handiest cloth; the length should not exceed 2 ft. 6 ins., if too long, they soon wear out. (*e.*) Washing up the runs separately is a most essential feature on all dredges dealing with fine gold, and not only should the cloths on each run be capable of lifting while the dredge is at work, but means should be provided to allow of their being cleansed from sand (consequent on the stoppage) when in full work. It will be noticed on the plan given by Mr. Richardson that the run divisions appear at the lower end of the spreading-tables. A movable cover is made to fit and stop the run, the water-trap in the auxiliary water-supply tank is then lighter, and the required amount of water allowed to pass into the run. When the cloths are sufficiently cleared from the useless *débris* the water-trap is shut down, the cloths lifted, washed, and when replaced the cover is lifted and the run is at once at work. (*f.*) The present system of letting the saving-tables look out for themselves is not desirable. It will be found that the money paid in wages for an extra hand will soon be repaid, more especially on dredges dealing with fine gold associated with black sand. The boxes suggested will require more deck-room and the adjustment of the position of the boiler, and the tailings-elevator gearing and belt, matters of no consideration as compared with effective saving appliances. In dealing with magnetite and black sand, which is apt to clog the cloths, perforated pipes, arranged above the runs at the required height to allow of the sprays falling upon the water running in the boxes, and causing a disturbance down the cloths, are a valuable addition to saving tables."

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* "Gold Saving on Dredges," by J. P. Smith. Report on Materials and Mines, New Zealand, 1903, p. 75.

Comparing sluice-box with tables, it may be said that the former can be used with advantage, in handling large quantities of gravel, where the gold is not fine; but, where there is much fine gold, tables are a necessary adjunct, or substitute.

(*d*) *Amalgamating Devices.*—There is reason to believe that the treatment of the material over even such extended surfaces as properly-designed tables present, does not suffice to collect the lightest and finest particles of gold. On this account, mechanical are occasionally supplemented by chemical means; gravitation and friction, by amalgamation, mercury being employed either in wells, or on plates, over which the residue from the tables is passed. The character of the gold obtained in dredging is seldom prejudicial to such methods. For while, on the one hand, its fine and often flaky nature makes it particularly hard to arrest by mechanical means, its cleanness, purity, and freedom from injurious minerals render it very amenable to amalgamation.

The employment of amalgamated plates in dredging operations is recommended by the Official Report on the Mining Industry of New Zealand, 1895, in the following terms: "In dealing with gold in the ocean beaches, it would be well for those having dredges employed in working this class of material to pay a visit to the ocean beach north of Charleston, and examine the appliances in use there. Instead of baize and blanketing being used on the tables, nothing is now required but copper-plates coated with quicksilver. The use of these on dredges would necessitate very complete machinery or appliances for separating the stones, shingle, and fine gravel from the sand, otherwise the rush of water and coarse sand would scour the plates; but, if this were done, the silvered plates ought to act as well for saving the gold on dredges as on the smaller tables used by the beach-combers at this place. The hull of the dredge would necessarily have to be large to admit of a sufficient number of tables to be used to treat the material in an efficient manner.[*] Not less than 50 ft. in width of these tables would be required to treat successfully the material lifted by one of these dredges. Wherever there is fairly coarse gold there is little trouble in saving it, but none of this class is found on the ocean beaches."

The use of wells in which mercury could be used was also proposed in one of the earlier reports, which suggested the employment of tables at the end of the main sluices, the tables to have a total width of 30 ft., a length of at least 12 ft., and to be divided by longitudinal divisions about 3 ft. apart, so as to form ten boxes of 3 ft. wide and 12 ft. long. These tables were to have three drops and splashboards, the bottom of each drop having the shape of the letter U, and forming a well in which mercury could be used if desired.

So far the use of mercury is not general, but the Welman dredge of the Six Mile Beach Company, Waipapa,[†] where the gold-saving appliances were very complete, adopted this additional means of recovery. The tables were 64 ft. wide, with a fall of 18 ins. to the 12 ft.; side boxes collected and carried all the tailings to the stern of the dredge. The material to be treated was composed principally of sand; the bottom consisted of a strong wash of varying size. The sand passing through the perforated plate was collected into a hopper, whence it was distributed with the water on to the various tables in equal proportions, each table being separately connected to the hopper-box by an independent run. The gold, which was extremely fine, was caught on the plush mats, the latter being washed every shift into the gold box. On the starboard side of the dredge, there was an apartment which contained an amalgamating barrel and special tables for saving the quicksilver and amalgam from the washings. Other and more recent dredges also, in various fields, have employed mercury in wells, &c.

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[*] The difficulty of providing space was experienced in dredging Snake River, Idaho. The gold was very fine, averaging about 1,000 colours to the cent. Screening and direct amalgamation were tried; and, while successful in a small way, never proved satisfactory on a large scale, because of the large surface required in the amalgamators. The difficulties involved in arranging and looking after copper plates or amalgamators for 400 to 500 tons per day, in the limited space of a dredge, made this method impracticable. On the Snake River, the only practically successful method of saving the gold is known locally as the burlap system. This involves screening to ⅛ in., and the sluicing of the screened material in broad shallow sluices or tables, covered with burlap or similar material. The sand is made to flow over these tables in a thin stream, and almost as much skill is needed for good work, as if they were copper plates.

[†] "Reports on the Mining Industry of New Zealand," 1891, p. 76.

(*e*) *Cyaniding.*—It is stated that a syndicate, owning the Waihi and Karangahake Dredging Claim, Ohinemuri River, New Zealand, intend cyaniding the auriferous deposits of the river bed, assaying about 15s. per ton. These tailings largely consist of the residue from the ores treated by the Waihi Gold Mining Company, in the early days of the field, when the cyaniding treatment had not yet superseded the pan-amalgamation process then in vogue. It is believed that, under that system, the tailings which were allowed to run off into the river contained about 4 dwts. of gold to the ton—a supposition which the assays referred to go to support. The syndicate propose to erect two plants, one at Waihi and the second at Karangahake, the latter to be worked by steam, and the former by electricity. The tailings will be lifted from the bed of the river by means of suction pumps, conveyed to the reduction plants, and there be ground in pans containing quicksilver and a weak solution of cyanide, and afterwards subjected to the ordinary treatment. The probable cost of the whole process is estimated at 5s. 9d. per ton, which would leave a good margin and make the venture self-supporting after the initial cost of the two plants has been recovered. The erection of these plants is shortly to be put in hand, and they will probably be ready to commence operations in about two months' time. It is considered that it will take a number of years of profitable work to reduce the whole of the auriferous deposits believed to exist within the boundaries of the claim.*

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* "The New Zealand Mines Record," August 16, 1900, p. 17.

X.—Process of Cleaning Up.

THE process of "washing up" and "streaming down" requires little explanation, having been already discussed in the author's "Hydraulic Mining."* The upper lengths of the mats and calico on the tables are washed once or twice a-day; the lower lengths, perhaps twice a week; and those in the sluices about once a week. The washing is carefully done in a large trough or box, about 2½ ft. deep by 4 ft. long and 3 ft. wide. The gold and sand obtained is then streamed down a miniature tail-race, consisting of an inclined flat wooden tray, about 12 ft. long and 20 ins. wide, at the upper end of which is a box, about 20 ins. square and fitted with a perforated iron tray bottom. Both box and tail-race are covered with mats of green baize, plush, &c., to catch the gold. The auriferous sand is scooped with a long-handled shovel from the washing trough into the tray box and washed through by means of a hose. The mats are then taken up and washed in an iron bath. The coarser gold is then separated from the finer by means of wide-gauze sieves; iron-sand is picked out by the magnet, or, when the gold is fine and much black sand is present, quicksilver is used to effect amalgamation. The returns are then dried, cleaned, weighed, and sealed up. The whole operation takes four or five hours to complete, according to the quantity of sands to be treated. As the black sands obtained in dredging operations frequently carry gold, it has been proposed to treat them by cyanide and other means; but none of these proposals appear, as yet, to have been put in successful operation.

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* Part III.

XI.—Percentage of Gold Saved.

Having described the various forms of dredges in use, and the operations of washing, separating, and recovering the gold, it may be well to inquire what percentage of gold is usually recovered. On this point there is diversity of opinion. The result of observations made by Mr. J. B. Jaquet,* supplemented by numerous engineers and other residents of Otago, is summed up in the following remarks: "The quantity of gold which escapes the well-equipped modern dredge is small, and it is not possible, under ordinary circumstances to profitably re-work ground." Again, "The percentage of gold which is lost in treatment upon the best-equipped dredges is probably very small. . . . Deduct 10 per cent. for loss in treatment (the loss under ordinary circumstances is nothing like as great as this). . . . The percentages of gold extraction (on dredges in Montana) is stated at 98 per cent."

Robert Bell states that the fine gold in the Snake River beds is recovered on a commercial scale up to 95 per cent. of the gross contents of the gravel. The fine material after separation from the coarser gravel by passage through a screen-floored sluice-box, is concentrated by gravity on burlap tables, the gold in the small quantity of concentrates being collected by mercury in a clean-up barrel. This method is simple, efficient, and adapted for operation on a large scale ("Engineering & Mining Journal," 1902, p. 241).

Mr. T. A. Richards, however, in his paper on "River Dredging in Otago," recorded as the result of earlier experience: "There is no doubt that the river receives back more than half of the gold contained in the material raised by the dredge. The tables at Waipori are somewhat larger than those of the Dunedin dredge (8 ft. long by 7½ ft. wide); but, in both cases, it appears the height of absurdity to think that they can save a large percentage of the fine flaky gold carried along in such a large flow of water and amid so great a volume of sand and gravel. The report of the directors of the Dunedin Dredge Company says that 'the dredge-master reports that the gold-saving appliances are all that could be desired.' This is the severest satire upon the childish efforts made to arrest the gold, fully 60 per cent. of which must be a mere passenger through the apparatus designed to arrest it. Over 100 cubic yards of gravel, together with the water employed to transport it, are in this case handled by the dredger every hour, and of this a very large proportion passes over the surface of the tables covered with cocoanut matting, whose dimensions are 8 ft. by 7½ ft. There is no opportunity whatever given for a separation of the gold from the mass of heavy black iron-sand, and the sediment in which it is enveloped. The surface over which it passes is far too small, and the distance over which it travels is altogether too short to enable it to be arrested by the simple means adopted. What is collected is in spite, rather than by reason, of the efforts made to catch it, and represents a small proportion only of the gold in the material, the larger part being lifted from the river only to be returned."

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* "Notes on Gold Dredging," 1898, p. 6 *seq.*

Mr. C. E. Turner* also writes: "It is comparatively easy to lift a large quantity of wash, and to elevate it after screening; but it is by no means so easy to separate and save a reasonable percentage of gold. It is an acknowledged fact among gold-dredging men that the design of the gold-saving apparatus is not all that can be desired. A plant that will save 90 per cent. to 98 per cent. in one place, if removed to a place a mile away might redeposit 50 per cent. of the gold contents among the tailings. The dredge master, therefore, has to be constantly on the alert in order to adjust his apparatus to any changing conditions which may present themselves."

The Report of the Minister of Mines for British Columbia, cited in the "Canadian Mining Review," January 30, 1903, p. 128, states: "At Lytton, the old Cobeldick dredge has been working. Here Mr. Turner, the director who was sent out from England to investigate for the company the working of the dredge, made the discovery that, of the gold dredged up from the bottom, less than 10 per cent. was recovered on the tables, the remaining 90 per cent. going off again with the tailings, although the gold-saving appliances on this machine were about the most complete of any in British Columbia."

Mr. F. T. Seelye, in his "Gold Dredging in Otago" ("Transactions, Australian Institute of Mining Engineers," Vol. IX., Part II., 1903, p. 187), says: "Leaving out of account the gold which is not raised, there is still a great loss of gold owing to imperfect treatment. The gold loss consists chiefly of the finer stuff, though nuggets of any size, which are believed to be rare, would be unable to pass the screen holes and would be lost. . . . The loss of fine gold is due to the very rough classification of the material, the comparatively small dimensions of the tables, which cause a great rush of water over the tables, and the presence of clay, which often causes a very serious loss indeed; . . . the clay formed from mica-schist is much more friable and less detrimental than the stiff and tenacious clay formed from clay-slates, &c. Black sand, when it occurs in any quantity and the gold is fine, clogs up the mats and renders them useless for gold-saving purposes."

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* "Gold Dredging in New Zealand," "The Mining Journal," December 13, 1902.

The author has not had opportunities of personally collecting sufficient data from which to deduce any actual average yields, and doubts whether dredging companies ever so closely determine the gold contents of the material in bulk, as to enable them to determine the exact percentage of gold recovered.* But, when the fineness of the gold is considered, and the limited table area available for its recovery, together with the disadvantages under which, on dredgers, such tables labour, it is difficult to believe that such perfect extraction as 98 per cent. is anything but exceptional, if not impossible. Probably, if the matter was closely examined, the best-equipped dredgers would be found to recover not more than 75 to 80 per cent., and, perhaps, only 50 to 60 per cent., when there is much clay or black sand. Certainly the fact that dredgers often work and re-work the same ground with nearly the same results indicates that the gold recovery is not so very perfect.

An opinion has been expressed that it is not the gold that passes over the tables which is lost, but that which, through insufficient washing and separation in the trommel, fails to reach the tables.† This is especially likely to be the case when clay is mixed with the wash. The finer gold is then liable to be carried away in suspension by the thick, muddy water that runs over the tables, while the lumps of clay that pass through the cylinder are apt to bear away with them many particles of coarse gold. In order to break up the clay as much as possible, bars, spikes, &c., are sometimes fitted inside the revolving trommel, or an endeavour is made to pick out and puddle the lumps of clay, before further treatment. Loss of gold may occur also through imperfect washing of gravelly dirt, some of the gold passing out of the cylinder with the stony material. Nuggets of any size, if present, will also be lost, since they cannot pass the perforations in the trommel. This loss, it has been suggested, might be avoided by intervening a small sluice between the trommel and elevator. The occurrence of nuggets is, however, very rare. Even under favourable conditions, fine gold is easy to lose, especially when much black sand is present, as the matting then speedily becomes clogged with iron-sand, and thus acts very imperfectly as a gold saver.

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* Mr. J. Hayes, inspecting engineer, Mines Department, N.Z. (Report 1899-1900, pp. 41, 42, says: "I know only of one case where a dredge master has actually taken the trouble to systematically ascertain the loss of gold carried away by lumps of clay and clayey water, when dredging flats and banks, carrying a clayey overburden. In this case it was found that gold amounting to 2 grs. per cubic yard of tailings treated was lost. This may be taken as a fair index of what is going on where the auriferous wash is overlaid by a heavy subsoil and clay. The most natural way to overcome the difficulty appears to be the adoption of a system of first stripping the overburden from off the wash."

† "Engineering & Mining Journal," August 18, 1900.

XII.—The Quantity of Water Required for Washing and Gold Recovering.

On most bucket and grab dredges the water required for washing and gold-recovery purposes is raised by centrifugal pumps, and preferably warmed by drawing it through the condenser. In some cases the lifting means employed are buckets, usually of about 5-gallon capacity, fixed to the rim of a wheel, set on the main shaft or at the side of the dredge. It is, however, preferable to use an independent engine or motor, thus more efficiently controlling the amount of water supplied to the screens, tables, and sluices.

The quantity of water used for the above purposes will be seen from the following table, compiled by the author from official sources: —

Locality where the Dredge is Working.	Hourly Output of Solid Matter.	Quantity per Minute of Water Used for Washing, &c.
	cubic yards.	gallons.
Waipori, New Zealand	57	3,000
Shotover, New Zealand	44	1,500
Greymouth, New Zealand	53	2,000
Jutland, New Zealand	52	2,000
Clutha, New Zealand	31	750
Clutha, New Zealand	44	1,500
Clutha, New Zealand	60	1,125
Total	359	11,875

These statistics show that the average amount of water used for washing, &c., is, roughly, 1,980 gallons per minute, or nearly 9 tons of water, for every cubic yard of solid material raised per minute.

A special pressure pump is frequently added for producing a strong jet into the drop shoot, trommel or screen, or for cleaning the buckets in clayey ground.

XIII.—Disposal of the Tailings.

In dredging, as in hydraulic mining, the disposal of tailings is frequently a source of considerable difficulty. The method of discharging *débris* at each side of the dredge is unsuitable for working shingly river-beds. In such rivers the material often contains from 60 to 70 per cent. of stones and coarse gravel, and this quantity, discharged overboard on either side, speedily hampers all movement of the dredge. Moreover, there is always a tendency for the tailings to find their way back again into the excavation made by the dredge. The first attempts to overcome these evils lay in raising the top tumbler, and so causing the dirt to be discharged at an elevation sufficient to enable a long shoot being carried over the stern to discharge the *débris* at some distance from the dredge. But the lifting of the material to a height that would suffice for the *débris* to slide automatically down a shoot, extending some distance astern, involved a large expenditure of extra power, and otherwise impaired the efficiency of the vessel. For this reason a more positive remedy was sought. Inventions for this purpose variously took the form of flexible steel-wire travelling rope-belts and of travelling grizzlys, such as that designed by Capt. Parker; or, again, of a tailings-pipe, through which the *débris* was forced by a jet of water under pressure, and discharged a few feet astern of the dredge. The Welman dredge at Waipapa* was thus equipped, the *débris* carried to the stern of the dredge, being received by a 15-in. diameter tailings-pipe, and conveyed on to the beach, gravitating thence into the sea. The tailings-pipe was fitted with a universal joint, and suspended from a post crane, so that it could be swung in any direction where it was desired to deposit the tailings.

But a later and more successful appliance for the disposal of *débris* in dredging is the tailings elevator, stated to have been designed by Messrs. Cutten Brothers, civil engineers, of Dunedin. In 1894—5 the first of these machines was in use on the Enterprise dredge, at Alexandria,† where it proved a great success. The elevator, roughly described, consists of a ladder constructed in the form of a box open at the top and latticed at the sides, forming a girder, and provided with a tumbler at each end. The apparatus is secured to two beams, bolted to the deck. The ends of these beams project over the stern of the dredge, and carry the bottom tumbler. There are also two upright beams bolted to the deck beams. The ladder has two stays of 2½-in. by ½-in. iron, extending from the top of the latter to the top of the uprights, and thence to the top of the main tumbler shaft-frame. There are also two stays of ⅞-in. round iron, running from the top of the ladder to the deck; buckets, boxes, or trays travel over the tumbler at each end of the ladder. These buckets are of steel plate ¼ in. thick, and are coupled by steel links rivetted to the bottom and steel pins and bushes. This forms a belt, the same as for a conveyor. The buckets are on four rollers running in hard cast-iron bushes. The lower tumbler is fitted with screws so that it can be lowered when required to take up any slack, as the joints of the tray belt wear. The elevator is driven by shafts with bevel wheels and pinion from the main engine shaft. Elevator buckets are perforated, so that any water may drain off. In working in a paddock especially, it is important not to carry water up to the top of the elevator, as it would wash the stacked material down, under the stern of the dredge, and might cause it to ground. Messrs. Marshall, Sons, & Co., Limited, in their dredging catalogues, thus describe the appliances for disposal of *débris*: "The tailings elevator consists of a series of buckets, into which a shoot from the revolving screens drops the tailings, travelling over rollers and tumblers at top and bottom end. The elevators are in some cases driven from the lower end, and in others from the top end. In some cases of dredging, it is necessary that the sand and fine stuff have also to be elevated. This is effected by allowing the tail-race to discharge into a sump, at the stern of the dredge, and dredging the material out of the sump into the elevator buckets."

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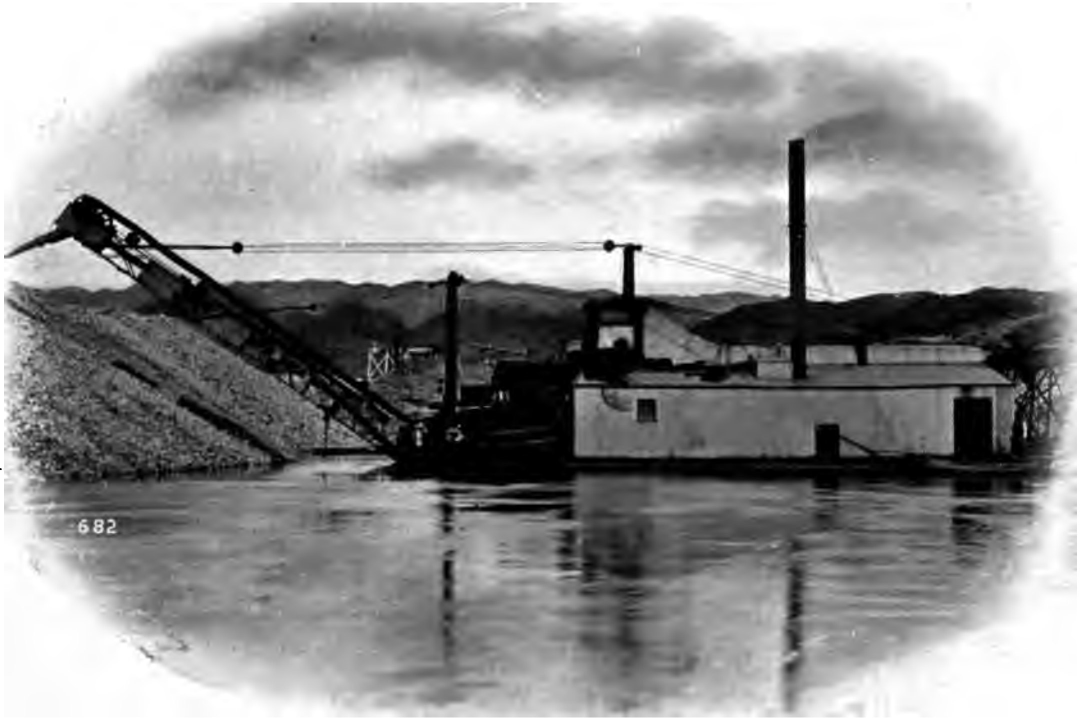
* "Reports on the Mining Industry of New Zealand," 1891, p. 76.

† *Ibid.*, 1895, p. 155.

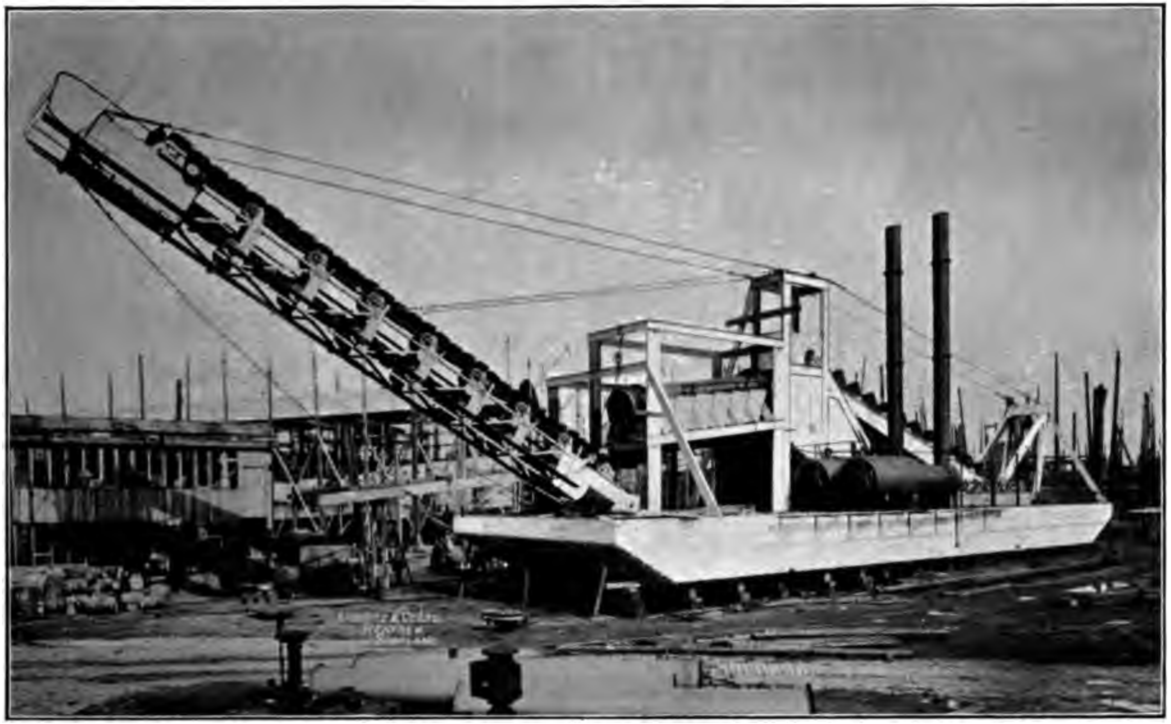
In many cases, bucket elevators are being replaced by the belt elevator. While the former entail considerable wear and tear, noise, waste of power, and liability to sudden breakdowns, the latter are more durable, noiseless, more economical in power, and give timely warning, if breakage is going to occur. In their belt elevators, Messrs. Fraser & Chalmers, Limited, claim that the belt itself will last for years, the centre where the greatest wear takes place is specially reinforced, and the idlers, &c., are all designed for easy and dust-proof lubrication. Another advantage is that this type of elevator can be driven as well from the receiving as from the head end.

Another device, specially suitable for dredges working in paddocks, is the construction of a sump, at the end of the pontoon. The fines, after passing over the tables, are discharged into this sump, and then removed by a sand-pump or by an auxiliary string of buckets, the silt-elevator tipping into the main elevator. This latter arrangements is used, among others, by the Araluen Proprietary Company, and prevents the silt being discharged into the paddock, but its maintenance naturally increase working costs. Some few years ago Mr. Roberts designed and

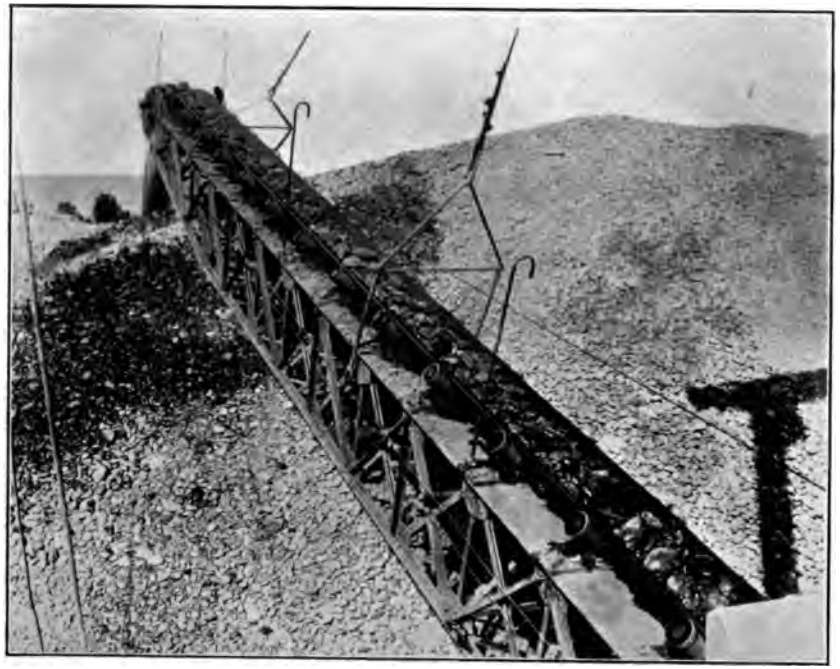


Gold Dredger, built by Messrs. MARSHALL, SONS, & COMPANY, LIMITED, Gainsborough, England.
Elevator at Work, Stacking Tailings.

66–A

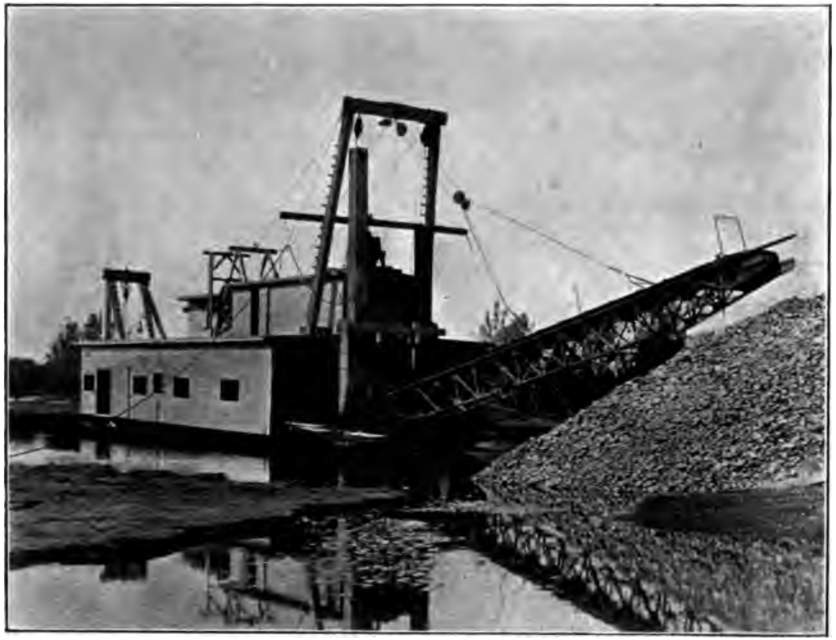


General View of Dredger, manufactured by Messrs. Lobnitz & Company, Limited, showing Bucket Tailings Elevator.



Belt Tailings Elevator, as manufactured by Messrs. FRASER & CHALMERS, LIMITED.

68—c



~~One of Messrs.~~ FRASER & CHALMERS' Dredgers, ~~with their~~ Belt Tailings Elevator at work.

68—D

Bucyrus Dredge – [illegible]

patented a silt elevator of an entirely different type, which, doing away with pins, links, and bushes, eliminates this source of wear and tear. This type of elevator has been lately fitted to the Gold United dredge at Duffer's Creek, West Coast, and is said to be dealing successfully with the silt from a dredge of 5½ cubic feet bucket capacity, running twelve per minute. The appliance consists of a light, strongly-made steel wheel somewhat resembling a water-wheel, fixed alongside the main elevator, but overhanging the stern of the dredge. The rim of the wheel is trough-shaped, with buckets or vanes about 14 ins. apart. The silt from the tables being deprived of a considerable quantity of the water, by a by-pass, is allowed to drop into the angular trough formed by the rim of the wheel, at the lowest place, and the wheel revolving at a slow speed carries the sand upwards and delivers it to an apron or hopper overhanging the buckets of the main elevator in a semi-dry condition, the surplus water being carried away by suitable shoots. The steep angle of the apron allows the sand to slide quietly on to the buckets of the main elevator, which then mixes both rough and fine material together. There is no tank or sink, and consequently no difficulty is experienced in restarting the elevator. The first cost is stated to be about one-half the cost of the small bucket elevator. A silt-wheel, provided on the Earnscleugh No. 3 electric dredge, lifts about 70 per cent. of the finer material from the tables, which is then run into the main elevator-buckets and deposited on the tailings-dump, and on becoming mixed with the coarser material the tailings-heap stands up firmer, and the tailings also assume less bulk than if the silt were run into the paddock from the tail shoot in the usual way.

As a rival to the wheel or the bucket elevator, Messrs. Payne & Peck, of Dunedin, have invented the centrifugal tailings elevator. This consists of a wheel or drum, with beaters or vanes, somewhat similar to a water-wheel. The tailings are delivered on to the periphery of the drum, and, being struck by the revolving beaters, are projected in the required direction. The advantages claimed are lower first cost of the elevator; lower cost of the dredge, since less space is required, and no poppet heads are needed; lower maintenance cost, as there are only four wearing surfaces and two bearings, in place of tumblers, rollers, links, pins, bushes, &c.; the tailings are evenly distributed, instead of being stacked in heaps. This form of elevator has been introduced on some dredges, and is said to be working satisfactorily.

It may be interesting to note the compass into which dredge tailings will stack up under different conditions. A dredge, discharging the whole of the wash-dirt through a single sluice-box, will require about 20 per cent. more space to stack the tailings than they occupied *in situ;* but one fitted with a trommel will require fully 33 per cent. more room. This is due to the fact that, in the latter case, the fine dirt is separated from the coarse, and gets only partially re-mixed when discharged at the stem by the two shoots. Lastly, the tailings from a dredge, with an elevator, need nearly 50 per cent. more space for stacking. In this case, a fines sump, and, assuming an auxiliary bucket chain is not used, the fine dirt, and all that passes through the perforations of the trommel, is delivered close under the dredge stern, and settles on the bottom, while the coarse dirt and stones are carried up the elevator and stacked on the top of the fine stuff, which gets no chance of being mixed with the stones. The interstices between are not filled, consequently much more space is required.* In working into a high bank, therefore, a dredge builds behind itself a heap a good deal higher than the original surface of the bank. Hence, for working a 25 to 30-ft. bank, the elevator must be long enough to stack the stones to a height of 40 ft. or more.

The introduction of the tailings elevator, now widely in use, has greatly benefited the dredging industry. While the old machines, without this appliance, were confined to river operations, the new dredges, fitted with the elevator, have successfully exploited low-lying auriferous flats, and high banks, where the dredge might either be grounded or unable to reach the bottom in consequence of the tailings coming back on her.

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* "Reports on the Mining Industry of New Zealand," 1899, p. 143.

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XIV.—Working Costs.

THE difficulties of ascertaining costs in any mining business are almost insuperable. This arises partly from the unnecessary secrecy maintained by those conducting such operations; and partly either from the absence of methodical book-keeping, or from the want of uniformity in debiting charges—unfortunate facts to which the author has, on other occasions, drawn attention. Accordingly, the few data here given are far from satisfactory, for, though the capacity of the dredger and the working expenses per week are stated, neither the number of hours run, nor the total number of cubic yards dredged, nor the items included in the expenses can be ascertained. In very many cases, it is believed, the working expenses stated are merely operative, and do not include such items as taxes, amortization, and company expenses. With this provision, the following statistics are offered:—

The official Report of the Mining Industry of New Zealand for 1893* (page 128) states: "It is found that the working expenses of the dredges, for the quantity of material lifted, is not more than the expense of working ground with an hydraulic elevator."

The estimated weekly cost of working the Welman suction dredge, Waipapa,† raising, say, 30 cubic yards per hour, or, say, 4,000 cubic yards per week, including manager and eleven hands, wear and tear,‡ and 18 cords of rata firewood, were £70. In other words, the operating expenses were 4.5d. per cubic yard.

The working expenses of the Dunedin bucket dredge,§ with a capacity of 106 cubic yards per hour, were £250 per month, or £62 10s. per week; being £160 wages of nine men and a dredge master; £30 for coal, at 55s. per ton delivered; and £60 for repairs and supplies. The average of steady work being only four days per week of six working days, the daily cost would in this case be £15 12s. for an hourly capacity of 1,106 cubic yards. Assuming the dredge to work night and day, but deducting 25 per cent. for stoppages, unfilled buckets, &c., the total material dredged per day would be 1,908 cubic yards at a cost of £15 12s., representing 1.9d. per cubic yard as the working expenses, as against 4.5d. in the suction dredge above mentioned.

The costs of the Golden Treasure bucket dredge‖ made by Marshall

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* "The Mining Journal," December 26, 1896, *et seq.* Westralian Mining Reports of 1896, Mining Reports, &c.

† "Reports on the Mining Industry of New Zealand," 1890, p. 89.

‡ This is mostly about the buckets; lips last from one to two years, and the pins, on which the buckets are hinged, about three months.

§ "Reports on the Mining Industry of New Zealand," 1893, p. 205.

‖ "Reports on the Mining Industry of New Zealand," 1895, p. 153.

& Sons, Gainsborough, England, with a capacity of 60 cubic yards in steady work, are stated to have been about £36, equivalent to £.6 for an hourly capacity of 1 cubic yard. Two men per shift were employed, and the quantity of lignite coal used was about 1 ton per shift. Assuming the dredge to work continuously for four days a week, the operating costs would be 3d. per cubic yard.

The working costs on the Hyde and Woods bucket dredge,* raising on an average 32 cubic yards per hour, were rather over £30 per week. Six men were employed to work the dredge day and night, and the amount of local coal burned was about 3 tons per 24 hours. On the same assumption as to the number of days' work, this represents a cost of 3.16d. per cubic yard.

In the two bucket dredges of the Electric Gold Dredging Company,† Kawaran River, dredging respectively 70 and 90 cubic yards per hour, the united costs are £100 per week. Thirteen men are employed on the dredges. Assuming the same conditions as before, the working costs would be slightly over 2d. per cubic yard.

The Jutland flat dredge, Waipori, dredged 74 cubic yards per hour, at a cost of 1.55d. per cubic yard, including all stoppages, repairs, and expenses.

Mr. Jaquet, in "Notes on Gold Dredging," 1898, gives the weekly costs of running in New Zealand a large dredge, raising, say, 90 cubic yards per hour, as follows:—

Fuel, 16 tons of lignite at 12s.	£9	12	0
Labour, five men at £3, and one at £5 ...	20	0	0
Repairs, office expenses, &c.	20	0	0
	£49	12	0

which, on the same assumptions as before, represents 1.6d. per cubic yards.

It is claimed for the Yuba River dredge, Cal.,‡ built by the Risdon Iron Works, with a gross capacity of 93 cubic yards per hour, that, for any ground not deeper than 60 ft. below water-level, or more than 20 ft. above, and not containing boulders of more than 1 ton weight, the material can be handled at from 3 to 5 cents (1½d. to 2½d.) per cubic yard. If the capacity of this machine is calculated, without deduction for water raised, imperfect filling and general delays, and increased volume of the gravel, when broken up by the buckets, the actual working capacity would be less, and the costs of operating would be proportionately greater.

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* "Reports on the Mining Industry of New Zealand," 1896, p. 154.

† *Ibid.*, 1897, p. 139.

‡ "Report of the Minister of Mines in British Columbia," 1897, pp. 495 and 496.

Messrs. The Risdon Ironworks, San Francisco, Cal., in their Gold Dredging Catalogue, state: "On the Bear and Yuba Rivers, we find the same character of bed-rock existing, and the study of the economic conditions governing the operations of the various fields, shows that, with the system of dredging used on the Feather, Yuba, and Bear Rivers, ground can be handled for four and one-half cents per yard, including all wear and tear, and depreciation.

On the "A. E. Graeter," Montana, U.S.A., with an output of about 60 cubic yards per hour, the cost of working gravel by steam power has been found to be 9 cents (4½d.) per cubic yard; but on the "F. L. Graves," where electricity is employed for power, this cost has been 4½ cents (2¼d.) per cubic yard.*

The above figures indicate, first, that the cost of operating bucket-dredges by steam power decreases as their size increases. This is chiefly due to the relatively lower wages, the labour being about the same, whether the quantity raised be 20 or 100 tons per hour; secondly, that, in bucket dredges of large capacity, the cost of dredging ranges from 1½d. to about 3d. per cubic yard, and probably averages about 2d. "Ordinary ground," say the Risdon Iron Works,† can be handled by the new improved dredge at from 3 cents (1½d.) per cubic yard, and ground can be handled from 60 ft. below the water level to 20 ft. above at a cost which, it is claimed, is less than that of any other known process."

On L. Gard's No. 2 dredge, which is a current wheeler, working in mid-stream, and lifting from 35 to 40 tons per hour, and employs one man per shift, the average cost of working is £14 per week. Taking 30 cubic yards as the average output, and making the usual assumption, this works out at .97d., or under 1d. per cubic yard—a very low figure.

Mr. Frank W. Griffin, M.E., in "The Gold Dredging Industry" (California Miners' Association, 1904), says: "The average cost of handling ground with a small machine of 40,000 cubic yards' (per month) capacity, is approximately 6¼ cents per cubic yards, segregated as follows:—

Labour	2.10	cents.
Power...	2.00	„
Dredge supplies	·34	„
Taxes and insurance...	.18	„
Maintenance and repairs	1.20	„
Sundries	·43	„
	6.25	„

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* "Gold Dredging in Montana," by E. B. Braden, "Engineering & Mining Journal," November 20, 1897, p. 695.

† Catalogue No. 16, 2nd edition, 1898, p. 4.

In the 70,000 cubic yard machine, this cost per yard is less than 5 cents.

A writer in the New York "Engineering & Mining Journal" recently stated: "Under favourable circumstances, and when working continuously, a large bucket dredge will lift and treat 1 cubic yard (loose measurement) for about 1d.; but the average cost is probably nearly double this."

And Mr. F. S. Clarke, in "A Few Notes upon Gold Dredging" ("The Canadian Mining Review," 1902, p. 27), observes: "The average figure for handling gravels with a bucket and ladder dredge should not, at the outside, exceed 3½ cents per cubic yard, including labour, fuel, &c. The writer, some years ago, dredged gold gravels for over twelve months at the rate of 2 cents per cubic yard."

The annual report of the Oroville Gold Dredging & Exploration Company, of San Francisco, Cal., for the year 1903, gives the summary of costs in cents per cubic yards of a $45,000 dredge as follows:—

Dredge crew, power, and operating supplies	2.52	cents.
Repair labour	.93	"
" supplies	2.65	"
Total operating costs	6.10	"
Superintendence	.38	"
Oroville general expenses	.28	"
San Francisco ditto	.17	"
Taxes and insurance	.38	"
Bullion expense	.04	"
Grand total of all costs	7.35	"

Mr. R. H. Postlethwaite, in the New York "Mining Magazine," January 1, 1905, p. 10, gives the cost of other Oroville dredges as 6.45, 4.982, 4.92, 8.7, 3.66, 3.965, and 6.27 cents per cubic yard. The cost of power purchased varied from $\frac{9}{10}$ to 1½ cents per kw. hour; directors' fees, taxes, and amortization do not appear to be included.

The working costs given above show that the average expense of operating a steam bucket dredge in New Zealand, and perhaps elsewhere, amounts to 2d. per cubic yard raised. As, however, there are, in public company management, standing charges which are not included in this figure, it will be safer to consider the average full working costs in most parts of the world to be about 2½d. per cubic yard. Allowing 75 per cent. as the probable extraction, it follows that ground to be payable should contain in most cases 3⅓d., or, say, rather 1½ grs. of gold per cubic yard. This estimate agrees with other facts of which the author has cognisance. In 1892—3 the Waipari Gold Dredging Company was working a dredge raising 5,000 cubic yards per week, the average yield was 1.47 grs. of gold per cubic yard, and this seems to have been on the margin line between profit and loss. Other instances of a like nature could be cited. There are, of course, cases where 1 gr. of gold suffices to pay expenses and yield a profit; but, on the other hand, there are also cases where a much higher value is needed.

XV.—Capacity and Cost of Dredges.

As the working costs relatively decrease in proportion as the output is increased, it is clearly advantageous to lift as large a quantity of material as possible. But, on the other hand, it is waste of power to raise more material than can be properly treated. Hence the capacity of a dredge should be fixed by that of the gold-saving appliances. In other words, the capacity of a dredge is governed by the space at disposal for gold-saving. In accordance with this principle, practical experience is mostly in favour of limiting the capacity of the dredge to from 80 to 100 cubic yards per hour, or, say, 2,000 to 2,500 cubic yards of material per day of 24 hours. If more gravel has to be handled, it is better to employ two or more dredges. Not only does the first cost of a dredge increase out of proportion when its size passes a certain limit, but the parts of the dredge are so much heavier that the difficulty of making repairs increases, and the time lost from this is greater. The expense of maintenance also will increase. In spite of these disadvantages, the lower costs of operation favour the use of large-capacity dredges, and it is possible that machines of 100,000 cubic yards per month capacity may, in certain cases, prove the most economical. The total weight of a dredge of this description with all machinery is about 200 tons. In the close connected bucket type the rate of discharge ranges from 12 to 15 per minute; in the bucket and link type it is about 18 to 28 buckets per minute. It must be remembered that the amount of wash lifted by a dredge varies greatly. As a rule, the maximum is attained in large and deep deposits, where there is abundant material. But only in such ground, or where the dredge is working against a high face, the gravel of which falls readily into the buckets, is the theoretical capacity nearly attained. For instance, with fairly loose gravel of 12 or more feet in depth, and not less than 10 ft. below water, 4½ cubic feet buckets might, on a soft bottom, be expected to work up to seven-eighths of their full capacity. In most cases, especially when working shallow and hard ground, the actual dredge output is, perhaps, about 50 to 60 per cent. of the theoretical capacity. Where a dredge is scraping along or cleaning up a rocky bottom, with but a thin layer of wash on it, the capacity will be very much lower, for the buckets may be frequently checked by obstacles, and may come up almost empty. In such ground, an average output might be 33 per cent. of the theoretical capacity. In bad ground, where, for instance, a 5 to 10-ft. layer of wash lies on an uneven, rutty, clay bottom, consisting of rough boulders up to 4 or 5 tons in weight, all very tightly packed together and set with small gravel, the bucket capacity would be only about one-fifth or one-sixth of this theoretical amount.

Allowing for stoppages (oiling up every shift, washing mats daily, repairs, obstacles encountered, &c.), the number of dredging days in a week is usually about five. In the New Zealand Government's publication, "Minerals & Mining, 1902," page 104, the Warden of the Greymouth district writes: "There is one result which may be worth noting, that is that it indicates that the average working time of these dredges would be 42 weeks a year. I should imagine this to be a high average." In the district referred to, conditions are generally favourable, there being practically no stoppages for floods. It is notorious that dredges working in the River Molyneaux have to stop working profitably on account of floods for three, four, or even five months every year.

The necessity of continuous work for economy is impressed by Mr. Frank W. Griffin, M.E., in his paper on "The Gold Dredging Industry" (California Miners' Association, 1904): "To be successful, a dredge must be kept running as near 24 hours a day as possible, for when a dredge stops the producing part of the plant stops, while the expenses continue. Good judgment in the management of a dredge will minimise the time lost. Duplicates of the essential parts of the dredge should be kept on hand. All wearing parts should be provided for beforehand, so that when a break occurs it can be mended with the least possible delay. Care in this regard is more necessary in the dredge than in the mill, for in the mill you can hang up one battery for repairs or renewals while the others are working, but with the dredge the most trivial accident will stop the whole plant until repaired. Still, the dredge of to-day is practically on the same footing as the mill, and the loss of time due to mechanical causes is no greater in the dredge than in the mill. At the present time, well-managed dredges are making a monthly average of from 80 to 90 per cent. of the possible running time.* All stops of whatever nature are counted, including lost time for clean-up, power shut-downs and matters outside of the actual stoppages due to mechanical causes on the dredge. It is the usual practice to clean up twice a month. The time lost on this account is about four or five hours per clean-up. But this time not all dead loss, as it can be used to advantage in general repairs."

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* Possibly this may be the case in some fields; but in the Oroville field, California, for instance, the log books of dredges show the following percentages of actual time run to the total possible time—viz.: 72 per cent., 89.9 per cent., 85.4 per cent., 73.7 per cent., 75 per cent., 84.6 per cent., and 72.6 per cent. (See "Gold Dredging and Prospecting," by R. H. Postlethwaite. "Mining Magazine," January 1905.)

The speed at which buckets frequently dump, varies, from 12 to 17 buckets per minute, according to the nature of the ground. This gives a theoretical capacity for various sized dredges as follows:—

3¼ cub. ft., 87 to 120 cub. yds. per hour.
5 „ 132 to 190 „ „ „
7 „ 185 to 265 „ „ „

The actual capacity will, of course, vary considerably, according to the characteristics of the ground and the skill of the winchman. From May 20, 1899, to July 28, 1900, the Kia Ora 3¼ cub. ft. dredge, made by the Risdon Ironworks, and running 14 buckets per minute in fair dredging ground, but with a considerable number of stumps and timber, showed a regular weekly output of 70 per cent. of the theoretical capacity of the dredge.

XVI.—The Balance between Profit and Loss in Working.

THE line between profit and loss in dredging over certain fields may occasionally be gathered from reports. Such estimates, while no doubt tallying with the observations made, should not be accepted without full information as to the items included or omitted. As an instance of such demarcation, Mr. C. E. Turner, referring to New Zealand dredging may be cited:—

"The returns are never regular, so many vicissitudes tending to make them fluctuate; repairs, floods, timber, &c., all help to upset calculations, but anything averaging over 14 ozs. per week should pay. The greater the overplus, the greater the profit. For an average return of 25 ozs. per week, the figures would be as follows:—

Costs—

Manager	£6	0	0	per week (sometimes higher).
Engineer	4	0	0	„ „
2 Drivers at £3 ...	6	0	0	„ „
3 Winchmen at £3	9	0	0	„ „
1 General hand ...	2	10	0	„ „
Total wages ...	£27	10	0	„ „
Firing	14	0	0	„ „ according to situation.
Repairs	6	0	0	average.
Lubricants, &c. ...	1	0	0	
Office expenses ...	5	0	0	
	£53	10	0	Total weekly expenditure.

Several dredges under the one administration would show correspondingly diminished expenses. A dredge designed to lift 2,000 cubic yards per day of 24 hours would not accomplish more than 70 per cent. in actual work; this represents 1,400 yards per day, and six days would give 8,400 yards per week. This at 1.14 grs. of gold per yard would return 25 ozs.; at £3 17s. per oz., equals £96 5s. per week, less working expenses £53 10s., equals £42 15s. weekly profit; which represents £2,137 10s. profit per annum, or 21 per cent. on a capital of £10,000. Some returns have gone as high as 750 ozs. per week (a record). Several have maintained over 100 ozs. per week for months; but between 25 and 35 ozs. per week was an average for over 60 dredges in one district over several months of observation. The above figures will show that for the capital invested the gold dredging industry promises as high returns as any other industrial investment, with the promise of occasional plums of greater magnitude than are usually to be looked for. Many of the dredges in Otago, N.Z., did remarkably well on the small capital of £3,000, but they were generally owned by a syndicate of working dredgemen. In some cases, ground worked by old dredges has been re-worked by modern machines and made to pay a further dividend."*

The statement of costs is here rather misleading. It does not, for instance, allow for the necessary periods of enforced idleness, when all expenses except fuel, wear and tear, &c., are running on; nor does it provide a sinking fund for the eventual repayment of the initial costs of the property and plant.

A good deal of useful information is given in Messrs. Marshall's estimate of the commercial results attained by their dredges. "The working of this New Zealand (Molyneaux River) type of dredge is very simple, and two men per shift constitutes the crew which is required. It is customary to work day and night, which makes three shifts of eight hours each with a total crew of six men and dredge-master. The number of crew is not increased for the largest dredge which has so far been built. The working expenses are very small, which enables deposits which contain a few grains of gold to the ton to be profitably worked. The expenses on a large dredge will be about £23 per week for wages, £16 for fuel, and £14 for oil, stores, and wear and tear, which gives a total of £53 per week. This is the estimated expenditure on a dredge which will turn over about 170 cubic yards per hour. If we take the value of the gold at 2d. a grain, a simple calculation enables one to see the enormous profits which can be derived from this method of working alluvial deposits in the beds of rivers. Taking the value of the ground at one grain per cubic yard, which is very poor ground, the total value of gold which would be recovered in a week would amount to £131 3s. 4d.; and allowing forty-six weeks to the year, we have an annual profit of £6,033 13s. 4d. The cost of the dredge will amount to, approximately, £10,000, including everything."†

But here, again, what allowance has been made for lost time and accidents? And if the value of the ground is one grain per cubic yard, is it likely that this value will be raised and recovered? Where, also, is the redemption fund? As a dredge can rarely be sold for much when a claim is worked out, and is fit for little after ten years' work, it is important to provide an annual redemption fund, the amount of which depends partly on the life of the dredge itself, and,

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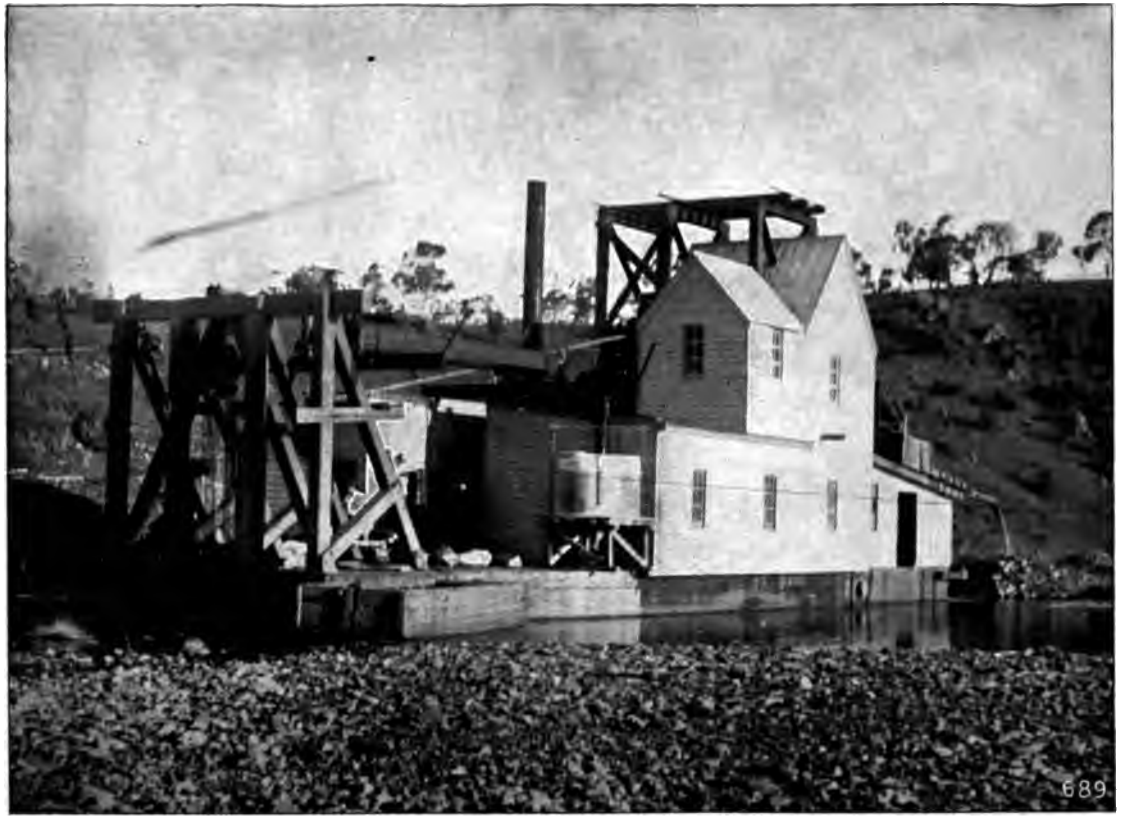
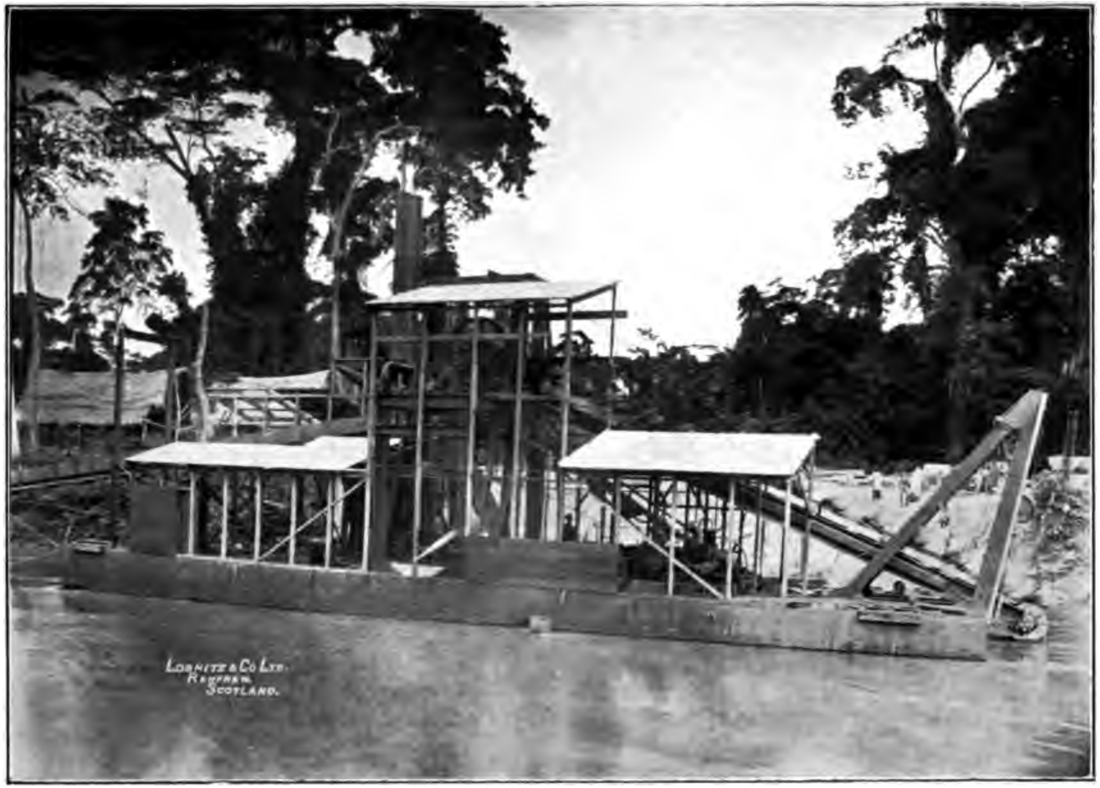
* "Gold Dredging in New Zealand," "The Mining Journal," December 13, 1902.

† "Gold Dredging," Catalogue No. 250.



A River Gold Dredger, built by Messrs. MARSHALL, SONS, & COMPANY, LIMITED.
Closed Protection against Cold and Wet.



A River Gold Dredger, built by Messrs. LOBNITZ & COMPANY, LIMITED.
Open Protection against Tropical Sun.

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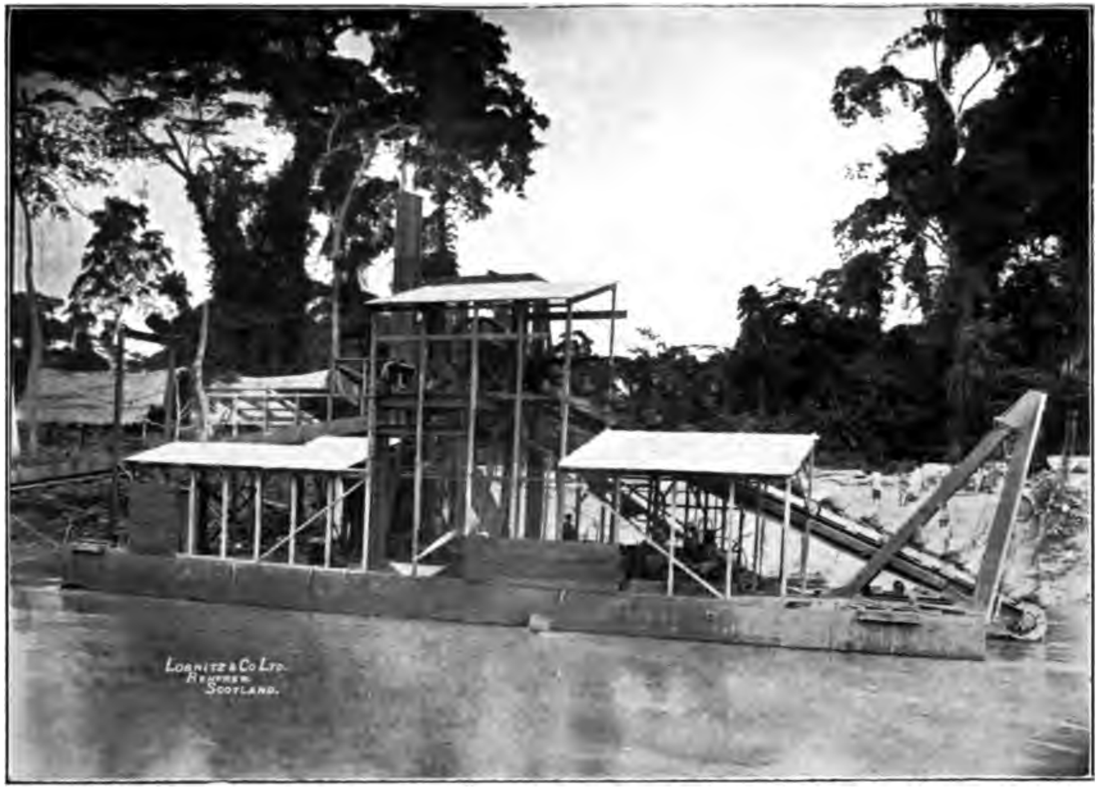
[*By permission of "The Engineer."*

[*By permission of "The Engineer."*



A River Gold Dredger, built by Messrs. LOBNITZ & COMPANY, LIMITED.
Open Protection against Tropical Sun.

in many cases, on that of the property. A New Zealand dredging claim, for instance, is nominally 100 acres, of which seldom more than 70—at times, only 20—acres can be worked. The life of the property, therefore, is often an important factor in determining the amortization fund. It should, in no case, be less than 10 per cent. of the original cost of the dredge, plant, &c., together with the capital value of the acreage worked out during the year.

Referring to a plot of alluvial of which, by the prospecting drill, the average depth has been found to be 11 yards, and the mean value 21.28 cents per cubic yard, Mr. N. Booth Knox illustrates how the prospects of a dredging venture might be figured out:—

"At an average of 11 yards deep, this ground will contain 53·240 cubic yards to the acre, and allowing 3,240 cubic yards for ridges and 'corners' left in dredging, we have 50,000 cubic yards per acre, or 10,000,000 cubic yards in the 200-acre tract under consideration. This at 21.28 cents per cubic yards gives a total contents of $2,218,000

Assuming the price is	$150,000
Cost of 5 ft. bucket dredge	65,000
Working capital	10,000
Total lost	$225,000

A 5 ft. bucket dredge is rated at treating 65,000 to 70,000 cubic yards per month, but up to the present time the best these dredges have been able to do has been about 70 per cent. of the possible running time. It may be added that the new dredges, now building, hope to do better than this, and will doubtless bring up the running time to 80 per cent. In fact, a new dredge, the 'Butte,' which has been running but three months, has during that time averaged 75 per cent., and the last month of their run they have averaged 86 per cent. of the time. Assuming 70 per cent. running time, a 5 ft. dredge will work out this ground at the rate of an acre per month, or, in all, about seventeen years for the tract. Assuming a working expense of the dredge as high as $3,500 ($2,500 per month is closer to a fair average of the month's expenses, even when allowing a sum of $500 for possible repairs), or $42,000 per year, and that one cent. per cubic yard is left in the tailings, then we have—

Total value in ground	$2,218,000
" " in tailings	100,000
To be recovered	$2,028,000
Total cost of treatment	714,000
Net gain in ground	$1,314,000

Net annual gain in 17 years	$77,300
Net annual gain per cent., 34.3 per cent., or allowing a sinking fund—17 years' life, annual contribution to sinking fund —to be at 3 per cent.	10,300
To be applied to dividends	$67,000
Gain per cent. per year on investment with sinking fund	30 per cent."*

Or the cost of equipment, operation, maintenance, depreciation, &c., say for a 100 acre claim, may be calculated as follows. The basis of figuring is from results as to capacity attained on the Feather River field, Oroville. Electric power is available at the low rate of $5 per h.p. per month for a twenty-four hour day. The annual profit shown has to provide for the company's standing charges, if any, and for repayment of the £15,000 capital at the expiration of ten years. In converting the coinage for this illustration, five dollars to the pound are taken:—

100 acres of land at £20	£2,000
1 dredge, 5-ft. buckets	10,000
Boarding house, blacksmith shop and tools...	500
Cash on hand	2,500
Cost per acre, £150 ... ... Total	£15,000

COST OF OPERATING PER MONTH.

Power, 75 h.-p., at £1	£75
Dredge master	26
3 winchmen, £18	54
3 deckmen, £15	45
Repairs and depreciation	80
	£280

Say £3,500 per year.

Ten acres per year, 30 ft. deep, worked, say, 500,000 yards per year, 4s.		£20,000
Expenses	£3,500	
10 acres land, at £150 ...	1,500	
		5,000
Profit per year...		£15,000

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* "Dredging and Valuing Dredging-Ground in Oroville, California," by N. Booth Knox, "The Canadian Mining Review," October 31, 1903, p. 212.

XVII.—The Selection of Dredges.

As Messrs. Marshall, Sons, & Co., Limited, in their dredging catalogues, remark, it cannot be too firmly impressed upon companies and those interested in this form of mining that one dredge will not be suitable for every claim, and that each dredge should be designed to suit its particular locality. Failure only will result, if proper attention is not paid to the value of the ground to be worked, the nature of the ground, and that of the gold; if attention is not paid to the design, loss of time through breakages will be excessive and cause a large increase in the burden of expense.

To enable a maker to estimate for a dredge, it is necessary to send the following information: Depth to bedrock from water level, depth of water, nature of gravel or wash-dirt, nature of bedrock, nature of gold to be saved, nearest railroad station, cost of carriage from station to dredging ground, cost of timber delivered on the ground.

The size of dredge to be employed on a given claim depends largely on the depth of wash-dirt to be dredged. If this is shallow —under 20 ft.—a small dredge costing £3,000 to £5,000 is best suited for the work, and would pay where a large dredge might be a failure. For dredging ground up to 35 ft. in depth, a £5,000 to £8,000 dredge would suffice. The largest dredges built have usually cost £8,000 to £10,000, and are capable of dredging to 60 ft. Dredges costing as much as £15,000 may be built, but it is not likely that this price will ever be much exceeded.

The Fraser Flat dredge, designed by F. W. Payne, of Dunedin, with 7 cubic feet buckets, and a capacity of 22,000 cubic yards per week, and arranged to stack the tailings and silt 80 ft. above water-level, is estimated to cost something like £14,000.

Messrs. Lobnitz & Co., Limited, of Renfrew, Scotland, have given considerable attention to methods of adapting standard dredges to varied and changing conditions of work. They build three different types, similar to those developed in the New Zealand rivers.

The A type has neither screen nor elevator, and suits best in a sandy bottom, or very small gravel, in rivers or the sea beach. It is fitted with a shoot over the stern, and would not suit for cutting into high banks.

The next, or B type, has the same application as A, but, having a screen, it has the advantage that, where the gold is difficult to separate from the soil in which it is embedded, it will extract a larger percentage of the gold from the spoil than the A type.

C type can do everything that A or B can do, and, besides, can cut into river banks or beds of gravel above water level, and, being fitted with a screen and elevator, can properly treat any gold-bearing river, or dry land where a little water is obtainable.

The type C has been greatly improved by the builders, who can pass the heaviest boulders through the screen by means of their special devices,* without in any way injuring the screen or the elevator. This saves much time, as, instead of having to stop to lift boulders out of the buckets, they can be safely passed out of the top tumbler along with the finer gravel, without any undue wear to the machinery.

As the builders have often to supply dredgers built to suit conditions of soil and working which are not accurately known, the designs are so made that type A can be converted into type B, or type B into type C. In this way the dredger, although ordered without knowing the purpose for which it is required, can be readily converted to suit it, even if a mistaken type were adopted in the first place.

All parts are correctly proportioned, so that no breakdowns can occur. Being manufactured accurately, and made by modern machinery, to gauges, of the most durable materials, and all parts standardised, ensures quick delivery of the most economical and tried machinery.

With a view further to make their standard dredgers adaptable to any spoil, Messrs. Lobnitz arrange their screen with the incline adjustable, so that it can be made to suit varying material. The steel gold-tables, also the tail-race and sluice-box, where fitted, have their inclines adjustable to suit varying conditions. The same applies to the elevator, and this can be made longer or shorter, as desired, by means of different positions being arranged for the upper tumbler.

The illustration shows the Kara Gold Company's dredger erected complete in Lobnitz & Co.'s works, the steel hull and framing and machinery all being fitted together, as if they were ready for work.

The gold-tables are arranged of ample height, and can be increased in area two to three times, if it is found that the gold is too fine to be caught on the standard surface, which is made ample for the average required.

The author thoroughly endorses three recommendations made by Messrs. Fraser & Chalmers, Limited, to intending purchasers. First, to drive the separate units of a dredging plant by separate engines; secondly, to have ample power in those engines; thirdly, not to cut down the initial cost to the lowest limit, as this means poor material and workmanship, with higher erection, maintenance, and running expenses. A dredge should be bought to work continuously and economically; and, considering the small saving in the initial expense, compared with the increased profits from a well-designed and economical plant, cheese-paring in this direction is false economy.

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* Patent No. 27,427, 1903.

R.P.	12 R.P.	—	3,250	7
R.P.	12 R.P.	—	—	7
M.	12 M.	—	—	7
A.	20 A.	—	—	6
R.P.	16 R.P.	15	5,500	8
Ro.	16 Ro.	—	—	—
M.	16 M.	—	—	—
M.	12 M.	—	—	6
R.	16 M.	11	7,160	7
R.P.	10 R.P.	—	—	7
M.	10 M.	8	2,464	7
A.P.	12 A.P.	10	—	7
M.	12 M.	14	3,650	7
M.	12 M.	12	2,515	7
M.	12 M.	9	4,478	7
R.P.	12 R.P.	10	4,300	7
M.C.	16 B.M.	—	3,000	7
M.	12 M.	—	3,100	—
M C.	16 B.M.	—	3,000	7
S.	15 S.	7	500(a)	7
M.	10 M.	8	4,000	7
P.S.	14	9	—	7
M.	16 M.	10	—	8
nston's	Patent Hydr.	—	—	—
Brien's	Patent Hydr.	6	—	7
Brien's	Patent Hydr.	4		4
S.	10 M.	14	—	8
Brien's	Patent Hydr.	6½	—	7
M.	10 M.	—	—	6
M.C.	12 B.M.	11	—	7
M.	12 M.	11	—	7
S.	10 S.	14	2,600	7
M.	12 M.	11	3,150	7
Brien's	Patent Hydr.	6	4,700	7
A.	12 A.	—	—	—
Ro.	12 Ro.	9	5,655	8
Ro.	12 Ro.	—	—	—
C.	12 M.	—	—	—
M.	12 M.	10	3,398	7
M.	12 M.	—	4,950	7
M.	12 M.	—	3.900	—
A.	12 A.	—	—	—
6 h.p.	Portable, K.	—	—	—
M.	10 M.	—	—	—

XIX.—Dredge Crews.

THE number of hands employed on a dredge varies from six to ten, divided into three shifts. The average crew, perhaps, consists of seven men—a dredge-master and six hands. As the dredges work day and night, with the exception of Sunday, there are generally only two hands on each of the three shifts—a winchman and a fireman. The dredge-master attends to the washing of the mats, the streaming down of the concentrates, the cleaning of the gold, &c., orders supplies, and does any clerical work required. Besides controlling the general working of the dredge, he takes part in the repair work. The winchman never leaves the winches, unless the buckets are stopped. He watches every bucket as it comes up, and slowly shifts the dredge along the cut that is being made. Upon the care and intelligence of the winchman, the success, and, when working in a river, the safety of the dredge depends. The fireman attends to the firing of the boilers, and looks after the main engine. He also does most of the odd jobs about the dredge. Some large dredges have a general hand, or an apprentice, for this class of work.

XX.—The Working of Dredges.

(*a*) *Starting Work.**—In the case of a river claim, the pontoons are built at some suitable spot on the bank, launched and fitted up with machinery. The dredge is then floated to the lower end of the claim, and thence works its way up the river. When moored at the point where operations are to be commenced, the ladder is lowered and the machinery set in motion. The buckets soon clear a hole, and the ladder is gradually lowered until the bottom has been reached and the wash containing gold cleaned up. The dredge is then moved sideways for about 18 ins. by slacking off the mooring lines at one side and hauling in those on the other side. If the bottom rises or falls, the bucket ladder is raised or lowered as needed, but the greatest care is taken to be always on the bottom, or, at any rate, never to get far from it, and to clean it up as thoroughly as possible at every point. By thus moving the dredge sideways, it can be made to travel from one side of the stream to the opposite side, without altering the head line by which it is moored. The line of the portion of bottom cleared is, therefore, slightly curved, being an arc of a circle described by the mooring as a centre, and the radius, the distance between the dredge and the head mooring. After one cut has been made across the claim, the dredge is hauled from 1 ft. to 4 ft. ahead, and the previous operation repeated. The dredge thus slowly works its way to the head of the claim. Any ground too poor to pay is left untouched as far as possible. At times the dredge may be working its way into the bank of the river, at other times, it may be working only a part of the river bed. The rate of progress depends upon a number of factors, as the size of the dredge, the width and depth of wash, nature of bottom, time lost in repairs, &c. On the average, a river dredge advances about 20 ft. a week, where the river is 300 ft. wide, and the wash is 10 to 15 ft. deep. A claim, 1 mile long, will thus be worked out in five years, unless the ground proves rich enough to be worked a second time. If the claim contains banks that can be dredged, its life will be lengthened in proportion to their size.

In the case of a claim on or near the bank of a river, the dredge, after being launched and fitted up on the river, starts operations by taking a wide cut from the river into the bank to the desired starting

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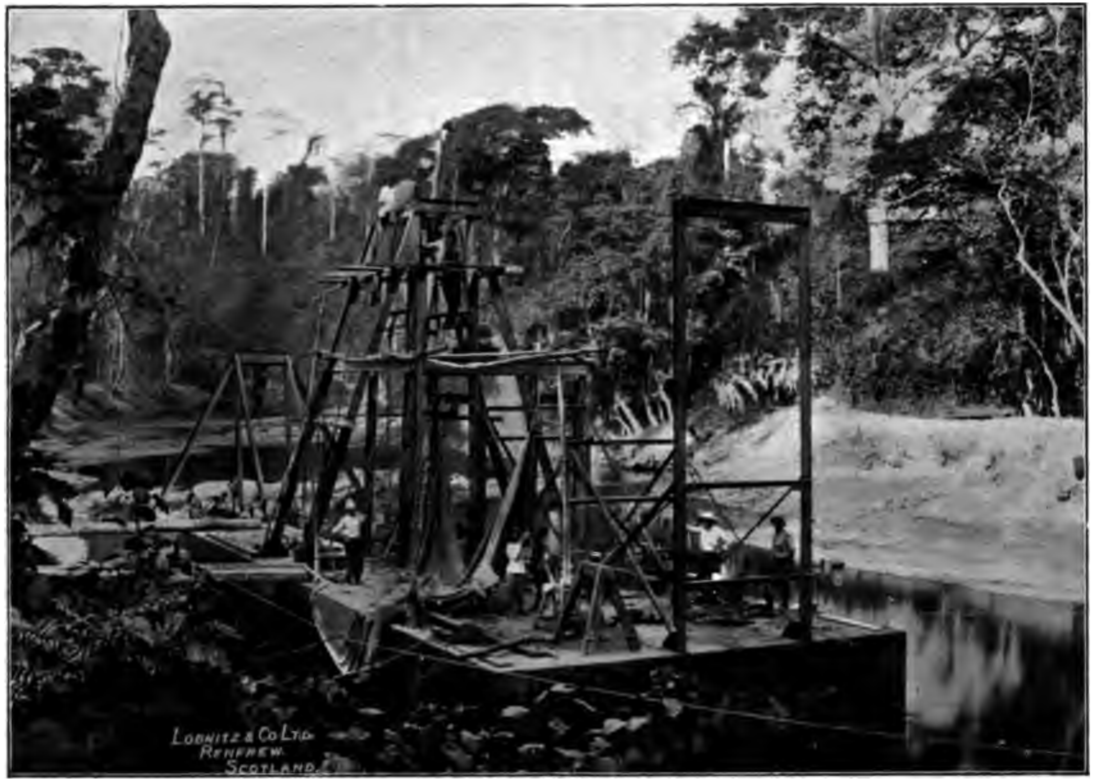
* *See* a contribution by Mr. P. G. Morgan in the New York "Engineering & Mining Journal," 1900, p. 162 *seq.*



Gold Dredger, supplied by Messrs. Lobnitz & Company, Limited. Renfrew, Scotland.
The Dredger being completed Abroad.

point.* Unless the ground is very little above water level, an elevator is necessary for stacking the tailings. If the dredge has to work an alluvial flat, some distance from any large river, a pond or paddock has first to be excavated for the pontoons. The paddock is enlarged by the dredge as much as possible, until finally a pond is made somewhat wider than the length of the dredge, and deep enough to float the dredge. Future operations then proceed by taking cuts across the claim, and gradually hauling the dredge ahead. It the claim is wide in proportion to its length, the whole width is not taken in one cut, but is worked in sections. The extent of ground worked by a dredge, on a bank or alluvial flat claim, varies according to the size of dredge, depth of wash, &c., from three to eight acres per annum. As the usual area of claims of this class in New Zealand is 100 acres, they may have a life, except when the ground is very shallow, of about twenty years, or if the ground can be re-worked, of thirty to forty years. More frequently, not the whole of the ground is workable, and the life is, therefore, proportionately less. Though very rich returns are not to be looked for from the dredges on the flats, yet their yields are often uniform, and it is evident that many of them will prove as, if not more, profitable in the long run than the best of the river dredges.

In an alluvial flat claim, the presence in the flat of enough water to float the dredge is the first necessity. In those cases, where the ground is not wet enough, either some small stream must be available for turning into the paddock, or water must be brought by pipes or water races from the nearest source. A supply of fresh water is advisable in all cases, so as to prevent the water in the paddock from becoming excessively muddy, and, therefore, unfit for use in the boiler or for gold-saving. For this purpose, from 250 to 600 gallons per minute, according to the nature of the ground, is usually ample.

Referring to New Zealand practice, Mr. C. E. Turner writes: † "The system of working a claim naturally varies with the conditions. In a river, work up stream from bottom boundary of the claim.

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* "In commencing operations, the buckets being in motion are gradually lowered into the wash, until the bottom is reached; from this a paddock is opened out, say 50 yds., or to any required width, by working over on the side lines with the head-line as radius, the dredge is then pulled 2 or 3 ft. forward on the head-line and worked back to the point from which it is started; this operation is repeated, and the buckets kept scraping the bottom all the way across. By adopting this method, the ground is systematically worked. Everything is taken in a face, and, when the dredge has worked forward its own length, the tailings are deposited in the paddock which has been cleaned up. A dredge putting through 120 yds. per hour is easily worked by two men, and the horse-power required, if under favourable conditions, is 45 to 50 actual."—Paper read by A. C. Perkins before the New South Wales Chamber of Mines, 1900.

† "Gold Dredging in New Zealand," "The Mining Journal," December 13, 1902.

If the river is wide, one side is worked first, some protection being afforded from flood by the stack of tailings. In pond dredging, local conditions must govern the starting point. If the bottom is level, and the gravel laid or tiptilted down stream, it may be better to start so that the face will fall to the buckets; but if the bottom rises, so that by working to favour the natural lay of the stones means losing the water—through the water maintaining its original level—then it may pay better to work against the lay of the wash, and so carry water in increasing depth in the advance. Across claim dredging would seem the most business-like way of working the claim, as then the runs or leads are known and numbered, and the commercial value of the claim proved. It will be easily understood that if a dredge happens to begin working on a comparatively barren strip between two leads, the company may be brought to grief, while dividends are lying on either hand. When dealing with a bank much higher than the dredge, and which does not fall readily, it is well to provide a strong jet of water to break down the face, to prevent its sudden falls, which may endanger life and property."

The following information communicated by some of the New Zealand dredge-masters* describes:—

Modes of working and moving the Dredge so that no part of the Bottom that can be easily reached will be missed by the Buckets.

Jutland Flat Dredge.—This depends entirely on the intelligence of the winchman, assuming that the dredge has winches which will correspond with the speed of the buckets. The speed of the winches for side movement should never be more than will permit of having a bucket on the bottom; fast winches are no good—they move beyond. It may be necessary to have fast winches in the river for other work, but for cleaning-up they are of little use. The intelligence of the winchman does all the work.

Evans Flat Dredge.—Where practicable—that is, where there is sufficient room between the stern of dredge and the tailings—I believe in working the dredge diagonally to the face, so that no part of the bottom may be missed. That is to say, supposing I work the dredge with the bows parallel to the face, and across the full width of it, in returning with the diagonal positions, I get whatever bottom may have been left in ridges by the previous parallel cut.

Manorburn Dredge.—Dredge is moved by steam-winch. Dredge is never moved more more than 1 ft. each feet sideways across face.

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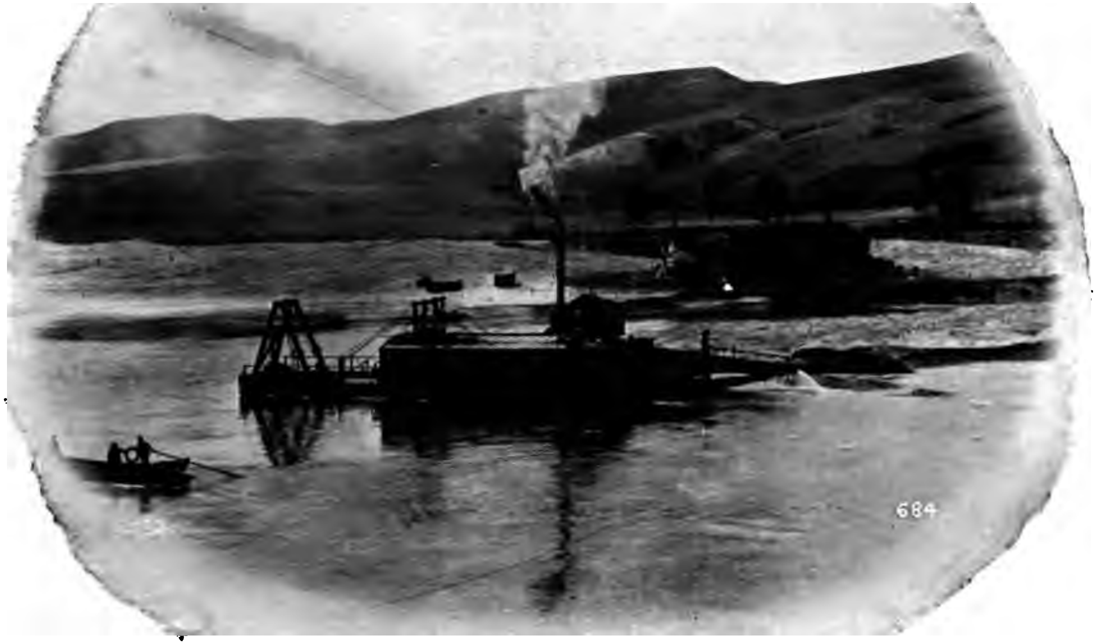
* "Reports Relating to Minerals and Mining, New Zealand," 1899, pp. 146—147.



River Dredging, showing Dredge at Work, Tailings, Stack, &c.
Gold Dredge, built by Messrs. MARSHALL, SONS, & COMPANY, LIMITED.

33—A

In taking feet ahead, cut varies from 1 ft. to 3 ft., according to nature and depth of ground.

Unity Dredge.—With the length of head-line as a radius, the dredge is moved across the cut with the side-lines, taking the wash in a face of any convenient width, the buckets being kept scraping the bottom. After the cut is finished, the dredge is pulled ahead from 1 ft. to 4 ft., and the same process gone through again.

Enterprise Dredge.—Take dredge ahead from 2 ft. to 4 ft., according to depth of ground working, and then work across the cut on the bottom.

Golden Terrace No. 1.—Pulling the dredge ahead about 4 ft. at one side of the cut, and keeping the buckets on the bottom. Pull the dredge sideways towards the opposite side, as the dirt becomes exhausted.

Alpine Dredge.—When once on the bottom, by taking the dredge about 2 ft. ahead at a time, and working sideways, the bottom is thoroughly cleaned.

Carrick Dredge.—Always keep the buckets on the bottom, and keep moving the dredge from one side of the cut to the other.

Buller Dredge.—After hauling ahead, say, 3 ft., which is the length of our cut, the dredge is hauled across the face by the side-line, the buckets always cleaning up the bottom, which is of soft clay.

(*b*) *Mooring and Moving Dredges.*—In New Zealand, the movement of dredges in rivers or shallows is seldom effected by the older, or, perhaps, more properly speaking, American method of "setts" or "spuds," but by winches operating wire-ropes fastened to the shore. Frequently the mooring, the moving of the dredge, and the raising or lowering of the ladder is accomplished by one winch having six to eight barrels controlling the various lines, as previously described (*see* winches). The advantages of this system are great. It enables the operator to rapidly shift the point of attachment—a matter of much importance when working on a rough bedrock with very large boulders; and it provides an elasticity or spring, given by the play of the lines, which makes bedrock work far less severe on the dredge than when the scow is solidly held.

In the States, however, the spud method is said to be still in use. Thus, the "A. E. Graeter," launched in 1897 for the Bannock Dredging Company, Montana, was equipped at the rear end with two spud timbers 42 ins. by 18 ins. by 50 ft. in size, and weighing 11,000 lbs. each. These were fitted with a pointed steel shoe at the lower end, and with the necessary gear for raising and lowering. The spuds for moving the dredge forward or backward, were alternately raised by means of hoisting cylinders of 24 tons capacity, and dropped after the dredge had been swung by the engineer, through cables passed around the front corners of the boat to a lateral anchorage. The boat was thus walked ahead. While excavating, one of the spuds rested in the gravel at the bottom, and formed a pivot, around which the boat was swung, as the gravel was taken up. The ladder was lowered about 6 ins., with each swing of the dredge around the anchored spud. Thus, with the drag of the bucket a segment of gravel 6 ins. deep and 8 ft. wide was excavated. This lowering of the ladder continued until bedrock was reached.

Mr. P. G. Morgan* describes the mooring and shifting of a dredge somewhat as follows:—

Dredge is moored by means of five strong galvanised steel wire ropes, one being a head line, and four side lines. The head line is carried ashore at a point from 900 to 1,200 ft. ahead of the dredge, and fixed to a log, which is securely buried some depth in the river bank. The side lines are similarly fastened, or more conveniently secured to some large boulder on the river bank. In some districts, trees are available. Dredges working on alluvial flats are moored in the same manner, but, in this case, the ropes need not be so strong or the logs so deeply buried. The dredge is moved ahead, and from side to side, by means of the winches already described.

When the dredge is working in a wide part of the river, anchors and chains are used instead of the shore lines; these latter, however, being always employed if possible. The diameter of the ropes used is, for side lines, usually about 1 in.; for head lines, a stronger rope of 1.25 in. diameter is required.

When a dredge is working in a strong current, a great strain comes on the mooring lines, especially during floods in the river, and it is desirable to provide a second fastening and line in case of accident to the chief head-mooring. During ordinary working, the grip of the buckets on the wash (a dredge always works up-stream) counteracts in some measure the force of the current, but, if the buckets should happen to slip over a stone or suddenly free themselves from an obstruction, the mooring lines will tighten with a jerk, which may break them, unless the winchman is on the look-out and neutralises the effect by slackening them off.

The several ways of mooring some New Zealand dredges, and of placing and shifting moorings, is thus described by their masters:—†

Jutland Flat Dredge, Waipori.—Moored by five lines in ordinary weather; with gales, preventers are put out—that is to say, heavy

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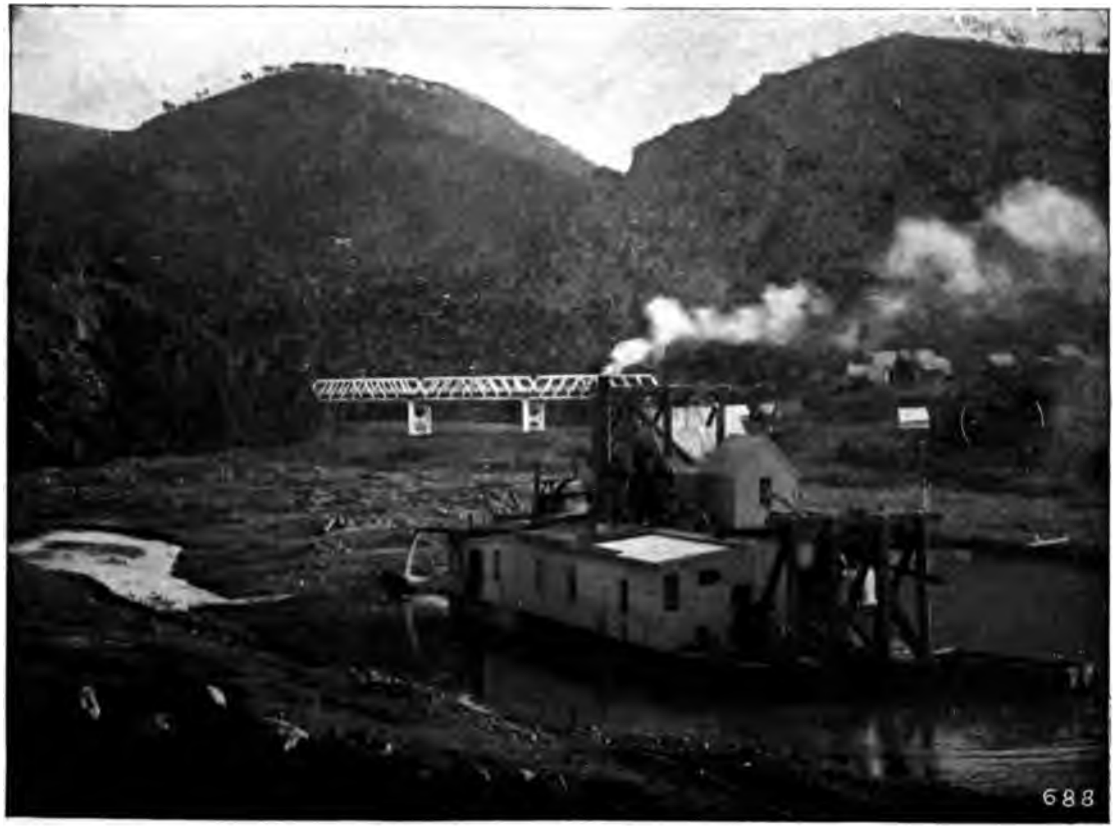
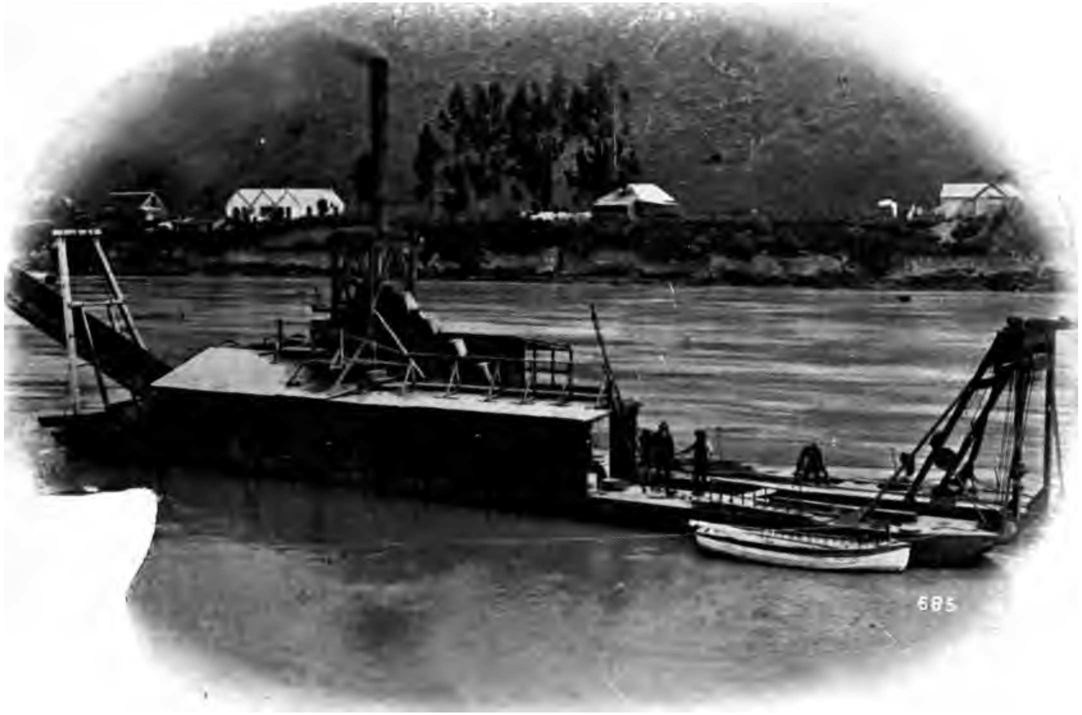
* "Mining & Engineering Journal," New York, August 11, 1900.

† "Reports Relating to Minerals and Mining, New Zealand," 1899, pp. 146, 147.



River Dredging—The Dry Season.

A Gold Dredger, built by Messrs. MARSHALL, SONS, & COMPANY, LIMITED.



River Dredging—The Flood Season.
A Gold Dredger, built by Messrs. Marshall, Sons, & Company, Limited.

manila lines on the weather side. The five lines are two for bow, two for quarter, and one head-line; and spare lines are according to requirement. Waist-line, stern, and preventers at right angles. Moorings are shifted, as a rule, without stopping. A manilla lien is put out to replace the steel mooring, while the dredge is being shifted. Lines are shifted with a boat by two or more men, as required. The moorings are placed to suit the work, about 120 degrees from the face.

Evans Flat Dredge, Lawrence.—This dredge is moored by one head-line, two bow-lines, and two stern-lines to pieces of 6 ins. by 6 ins. timber sunk to a depth of about 3 ft. Moorings are shifted as required, by going on shore and hauling "backers" forward into holes previously sunk. In working, the ladder is raised sufficiently from the bottom to allow of a "cut" being taken by the side-lines, such "cut" being rather less than width of buckets, the bottom of each "cut" being cleaned before again raising ladder.

Manorburn Dredge, Alexandra.—Flexible steel-wire ropes 1¾ ins. in circumference; side-lines and head-line, 2¼ ins. in circumference are used. The ropes are fastened to logs of wood buried from 2 ft. to 3 ft. deep.

Unity Dredge, Clyde.—One head-line and four side-lines (two bow and two stern) attached to sleepers buried in trenches above high water.

Enterprise Dredge, Alexandra.—For head-line, a hole from 4 ft. to 6 ft. deep and about 8 ft. long is sunk. Place backer in same, which should be a piece of blue-gum or some other strong wood not less than 6 ins. by 8 ins. Bend the line on to it with the pulling part at the bottom; side-lines in proportion. If working in still water, keep side-lines with a draw astern; in case of high winds it keeps dredge from being blown on to the face being worked.

Golden Terrace No. 1, Tucker Beach.—Two lines on each side and one in front, fastened to logs sunk in the ground, with a couple of piles driven in front to prevent drawing.

Alpine Dredge, Cromwell.—Moorings, wire rope; working cable up stream, and made fast to a backer sunk in the gravel; side-wires, four, two on each side of river, one being forward and one aft on each side, all connected to barrels on steam winch.

Carrick Dredge, Nevis.—Wire ropes, and backers sunk in the ground.

Buller Dredge.—When available, trees are used as mooring-posts. When they cannot be got, we bury a log, say, 5 ft. deep and make fast to it.

XXI.—Centrifugal and Hydraulic Dredging.

(*a.*) *Plant and Method of Working.*

ANOTHER form of so-called dredging, variously termed hydraulic dredging, steam hydraulic sluicing, gravel pumping, barge sluicing, centrifugal and hydraulic dredging, by steam or electric power, has been in use. The terms are rather misleading, as the method consists in employing a hydraulic jet to break up the alluvial, which is then washed into a sump or well, from which it is pumped into an elevated sluice line, the necessary plant for these operations being carried on a barge or so-called dredge. This barge or pontoon rests on dry ground when working, but as progess is made and it becomes necessary to move forward, a paddock, formed by damming, is flooded, and the barge floated into a fresh position.

In commencing operations, if the terrain is sloping, a site on the lowest level is chosen; or, if the ground is level, boring is employed to find the deepest spot available. Such a position is desirable, in order that the well-hole, from which the pump draws the gravel, may not require to be deep, and that the rest of the ground to be worked may have a tendency to fall towards this point, and thus the largest area possible may be exploited before the plant requires shifting.

Of plant, methods of working employed, &c., the following descriptions are abbreviated from the special edition of the "Australian Mining Standard," of June 1, 1899.* The plant adopted by the Hon. J. Wallace, at Yackandandah, Victoria, is constructed on a floatable barge, decked and covered with galvanised iron to protect the machinery. Its length is about 45 ft. by 30 ft. in width, and 4 ft. in depth. On this is erected a special type of centrifugal Rand pump with engines and boilers. The barges do not work floating, nor take up the gravel under water. They are grounded until it is required to move them nearer to the working face, when the site is dammed and flooded. Its floating capacity then enables the plant to take up a new position so quickly that the whole operation of moving the machinery and sluice-head is often completed and work re-started in one day. The barge being placed over the lowest point of the deposit to be worked, an excavation is made down to bedrock, the pump in the meantime working to drain the ground to enable this to be done. When bedrock is reached, the well is excavated and all the surrounding gravel and overlying material are washed down by hydraulic nozzles into the well, taken up by the pump, and delivered into the sluice, where the gold, &c., is saved. The sluice boxes are arranged at sufficient elevation to deliver the tailings clear of the excavation. When a "paddock" is cleared, the bedrock is carefully cleaned up, and all fissures, &c., flushed out, and their contents sent down to the pump. As soon as the faces get too far from the pump, a fresh "paddock" is again made on bedrock, and a new well sunk to command the ground in front. The area just abandoned is then allowed to flood till the barge floats, when it is towed into position. The pump then drains the water off, till the barge grounds, and work is recommenced. A low dam is made across the old paddock, behind the barge, and the tailings are dumped into this worked-out ground, thus filling it up, and leaving it much in the same condition, as it was before it was worked. The dam is raised as much as is required to keep the tailings back from the barge.

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* Page 91 *seq.*

The method adopted by the Ballarat Gold Dredging Company is described by Mr. Wilberforce.* The site having been selected, six piles are driven to bedrock. The sides are braced, and a pump fixed. The piles allow the ground to be sluiced away under the pump case without altering its position, they also ensure a firm foundation, and admit of the pump being lowered, if necessary. In very rotten ground, driving by intermediate gearing is compulsory, so that the engines and boilers may be kept back, well out of danger, unless they also are on piles driven to bedrock. When it becomes necessary to move the machinery, a 4-ft. deep pontoon about 40 by 50 ft., for a large plant, and 40 by 30 ft. for a smaller one, is built of large fir beams, caulked with hemp, tar, and pitch, and the machinery is so erected on it that the weight is evenly distributed. The giant nozzle used for breaking the dirt down is at times actuated by natural water pressure, or, if for this the depth of the ground is not sufficient, pressure may be artificially created by pumps.

(*b.*) *Sluicing Appliances Used.*

The length, grade, and dimensions of the sluices to be used depend on numerous circumstances, already elsewhere discussed. At Beechworth and Yackandandah, where "hydraulic dredging," or, more accurately, "gravel pumping" has been carried on more extensively than anywhere in Victoria, experience seems to have led to the adoption of a standard sluice line, described as about 120 ft. long by 4 ft. 6 ins. wide and 12 ins. deep, constructed of iron in twelve lengths, set on a grade of 7 to 9 ins. in 12 ft., and carrying about

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* "Australian Mining Standard," June 1, 1899, p. 162. *seq.*

7,000 gallons of water per minute. The first 30 ft. are fitted with ripples made of 2-in. and ¼-in. bars, corrugated into diamond-shaped holes, about 2 ins. by 2 ins., and covered with slot-punched plates, 12 ins. wide underneath. Blanketing is used to catch the fine gold, and mercury is used in the ripples. The lower portion of the sluice is arranged with blanketing and undercurrents for the fine material, while the coarse gravel and stones are carried over the slotted plates to the tail. The sluices are constructed so that they can be easily taken apart and re-erected, when the position of the barge is changed, and generally the first 50 boxes are carried on staging or supports from the barge, and the rest on trestles.

A modification introduced into some sluice lines is styled a "settling box." This box, built of 3-in. planks, braced with iron, and provided with traps on either side, is dimensioned to contain from 4 to 6 cubic yards of gravel. It is placed in the sluice line about 60 ft. from the barge, and receives the coarse gravel and large stones. As soon as it is full, the traps are opened and the stones fall into the dumping paddock immediately behind the barge, while the lighter material is carried further down the sluice and deposited on the top of the previous coarse gravel dump. The advantages of this method are that, by getting rid of the coarse material at an early stage, the grade of the rest of the sluice line may be reduced, consequently the initial lift for the pump is reduced, and, further, more favourable conditions for gold saving in the lower part of the sluice are obtained. Again, this method of dumping leaves the filled-in ground with the stones and coarse material at the bottom, and the rich fine soil on the top.

(*c.*) *Consumption of Water, &c.*

Where water is scarce, or in dry seasons, it may be necessary to dam the tailings water, and lead or pump it back for the use of the sand pump, and the hydraulic nozzle on the barge. Generally about two-thirds of the total water required by the sand pump can be returned in this way.

(*d.*) *Plant Capacity and Cost.*

In the Yackandandah district, Victoria, the common size of sand pump is one with 12-in. suction and 15-in. delivery pipes. The engine power varies according to the height of lift—that is, the vertical distance between the bottom of the suction pipe and the sluice head. The usual depth here is about 60 ft., and for this the 12-in. pump requires 130 i.-h.-p. in the engine. Owing to the enormous wear and tear due to the attrition of the sands or stones, all wearing surfaces should be provided with hard metal or steel liners,* and the pump shaft should be fitted with sand-proof bearings, supplied with clean water under pressure to keep the sand from entering.*

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* According to some, tough metal is best.

Such a plant will raise and sluice from 100 to 150 cubic feet per hour, together with from 350,000 to 450,000 gallons of water. The minimum quantity of water required is about 2,500 gallons for every cubic yard of gravel raised by the pump.

The cost of a barge and plant, as above, erected in this district is about £5,000. To this must be added the cost of the necessary surface works, such as wing dams, surface dams, sluice races, and drains for tailing waters; and also, at times, the cost of bringing in a water supply under pressure.

(*e.*) *Working Costs.*

The cost of operating a plant of this description in the districts mentioned, including maintenance, management, wages of miners and labourers, and all other incidental charges, up to the smelting of gold, and calculated over an extended period, on the basis of the actual ground worked from the grass to the bedrock, is stated to have varied in the more successful plants from 2.3d. to 2.8d. per cubic yard, where a natural head of water is available for hydraulicing. If nozzle pressure has to be generated by pumps, the cost is nearly doubled, or approximately, 3.5d. per cubic yard. The above figures apply only to working with a lift not exceeding 60 ft. At greater lifts the costs increase very considerably, owing to the lower efficiency in the type of pumps employed and greater wear and tear.

(*f.*) *Advantages.*

On this point, Mr. Wilberforce remarks, the advantages of the barge are the greater facilities it offers for removal, when the face gets too far from the well-hole; the fact that the pump is kept close to the bottom, a condition favourable to the efficiency of this type of pump. Again, the barge is a great safeguard should the claim at any time be flooded, as the barge will instantly rise, and carry the machinery out of danger.

The system adopts itself to the treatment of dumps of alluvial tailings, gold-bearing gravels, and drifts in the beds of creeks, and to the working of low-lying flats.

It may be asked why the bucket dredge would not be as good or better than the centrifugal gravel pump. Where there is not much slope on the bedrock, and the ground is fairly even in depth, doubtless the bucket dredge would be a better appliance; but if there are buried snags, boulders, and rock projections, and uneven depth of ground, with a fairly regular slope of bottom, the centrifugal system should be applied. For these obstructions can be left *in situ* without seriously interfering with work; and, as the bedrock is afterwards run dry and cleaned out by hand, the gold that is apt to be left by the suction pipe is ultimately recovered. Moreover, the wear and tear of a bucket dredge working on a river is heavy; but it is infinitely greater, when there is not a running stream to keep the elevator-chains free from grit. While, therefore, bucket-dredging is preferable for the bottoms of running streams, centrifugal sluicing is usually better for areas that would be suitably worked by ground-sluicing, provided water-pressure, dumping grade, and other essential conditions were present.

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* Effected by providing, next to the stuffing box, an annular groove, in connexion with a small jet of water, under pressure greater than that in the pump.

(*g.*) *Conditions for Successful Work.*

The conditions necessary for success are thus stated: First, ground bearing a few grains of gold per ton; secondly, ground carrying no more water than the pumps employed can lift—or, alternatively, natural facilities existing in the levels for constructing drain-races to carry off the surplus water at the level of the bedrock (surface water flowing in the creek, if any, is diverted by wing-dams and races around the ground being worked); thirdly, a sufficient quantity of water under pressure to operate hydraulic nozzles to break down and carry the washdirt to the pump-well (this is usually obtained from a higher level, and brought down in pipes to the paddock being worked). If, however, no natural facilities exist to provide water at sufficient pressure for use in the nozzles for hydraulicing, then a second pump, with driving-engine, is fixed on the barge, and the water is brought to it in pipes at the best pressure obtainable, and is thence forced on by the pump, at suitable pressure, to the nozzles. The size of nozzle usually employed is a 4-in., with a pressure of about 70 lbs. This, of course, would vary according to the nature of the wash being operated and the size of the pumps on the barge.

The nature of the bottom and the character of the wash have also to be taken into consideration. A cemented wash does not yield to the force of the giant nozzle, so that a large amount of "pick work" is found necessary, entailing the employment of a larger number of hands than is necessary where the wash is free. A cemented bottom, on the other hand, is an advantage. A slate bottom with crevices is not satisfactory, as the gold finds its way into the crevices in washing down. Another bottom that is troublesome is the pipeclay. The gold will settle on the pipeclay, and, no matter how carefully it is scraped, a large percentage of the precious metal will pass away with the pipe-clay balls. The best bottom undoubtedly is granite, and the Yackandandah Creek, Woolshed, and El Dorado are advantageously situated in this respect. A granite bottom is easily cleaned, and there are no crevices into which the gold can sink, but as a rule all the gold can be driven into the head-race by the nozzle. The wash on a granite bottom is also loose, and practically free from cement.

More recently this method of dredging has been applied, in West Australia, to the treatment of alluvial areas previously worked over by dry-blowers. The apparatus, employed at Lindsay's mine, Coolgardie,* consisted of a portable barge with centrifugal pump elevator. This raised the material to overhead grizzlies and sluice-boxes. The coarse gravel was dumped alongside the machine, while the sands and sludge were separated from the surplus water by spitzkasten, the water returning to the sump for re-use. The thick stuff from the spitzkasten ran to a paddock to be drained. The barge was hauled from place to place, as required. The gravels were sluiced to the elevator pump by a water-jet thrown from a small centrifugal pump, and giant nozzle. Particulars of the test operation are supplied by Mr. J. Bennetts in a—

"Statement of Sluicing by a 4-in. Centrifugal Pump":—

Quantity of alluvial treated, 1,600 tons.
Number of actual days' sluicing, 20 days.
Gold obtained, 38 ozs. 5 dwts. 14 grs.
Value per ton, 11½ grs.
Quantity of water necessary and used per ton of alluvial, 200 gallons.
Water lost in sluicing, by Spitzkasten, and returning same direct to nozzle pump, 50 gallons, representing a loss of 25 per cent, or for 1,600 tons, 80,000 gallons as replenishing water.

The trial demonstrated:—

(1.) The complete saving of the fine gold.
(2.) A disintegration of all clay balls.
(3.) A satisfactory system of husbanding and returning the water for re-use.

The small output per day was due to a defective power supply, and inadequate size of the suction pump for the stones present.

There are very considerable deposits of this sort in various parts of the State, and now that water is more easily obtainable, the possibility of re-treatment is attracting attention to the problem. It is possible that the auriferous clay "pug" and "ironstone" lacustrine deposits of the Kanowna district† may prove amenable to similar operations.

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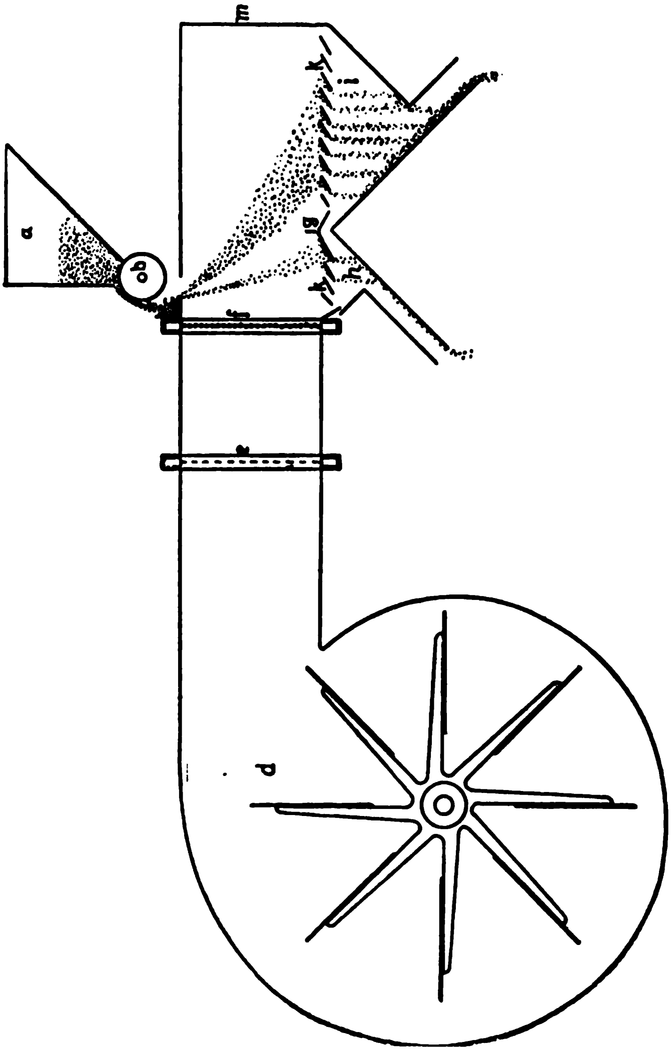
* Report of the Department of Mines, Western Australia, 1904, p. 86.

† *Ibid.*, pp. 63, 64, 65.

XXII.—Dry Treatment Excavators.

The existence, in various parts of the world, of placers having little or no water, renders it probable that, in such cases, the work of the floating or floatable dredge may, at no distant future, be performed by portable excavators and dry separation. About six years



Edison's Dry Placer Machine

ago, Mr. Edison took up the problem of producing such a process,* which, upon a large scale operates as follows: A steam-shovel excavates the gravel, and deposits it on grizzlies having a spacing that will allow the passage of the coarsest gold which the deposit is known to produce. The stones thus removed are left on the spot. The fines are trammed or mechanically conveyed to sizers. In passing by gravity through the screens, the gravel is divided into the number of sizes required by the character of the material, from four to eight. Each size of gravel coming from the screens is conveyed to a group of air separators, properly adjusted to treat their particular size of material. Passing under all the separators are two conveyors, one carrying the concentrate to the stock-house for final refining, and the other to the dump.

The essential features of the separators are shown in the illustration of an experimental plant erected at the Ortiz Mine, Santa Fé, New Mexico. The revolving roller *b* discharges the gravel from the hopper *a* upon the shelf *c*, from which it falls into the air-blast created by the centrifugal fan *d* discharging its air through the screens *e* and *f*. The parting-board *g* divides the heavier portion of the gravel—the gold and iron or black sand—which falls into the shoot *h* from the lighter portion falling into the tailings-shoot *i*. The lattice *k-k* is simply to prevent eddy currents of air going down the shoots *h* and *i*. The end *m* is open. By a suitable adjustment of the speed of the fan, the position of the parting-board *g*, and the rate of feed of the gravel, a concentrate was obtained, the details of which are given below.

Total gravel excavated, 33.8 cubic yards; weight, 137,464 lbs.; total gravel treated in mill, 38,896 lbs. This was divided among the five sizes as follows: A, 8,911 lbs.; B, 7,022 lbs.; C, 8,040 lbs.; D, 8,075 lbs.; E, 6,848 lbs. The results are shown in the following table:—

Size.	Amount treated. lb.	Weight of Gold in Concentrate. Milligrams.	Weight of Gold in Tailings. Milligrams.	Percentage of Gold saved.
A	8,911	513.2	147.40	77.7
B	7,022	1,737.5	66.65	96.3
C	8,040	3,478.0	75.70	97.8
D	8,075	3,667.0	340.46	91.5
E	6,848	2,542.5	26.41	99.0
Total	38,896	11,938.2	656.62	95.0

The concentrates are further treated, in order to reduce their bulk and increase their value, by passing them over an Edison magnetic separator, which removes the magnetic black sand or iron-ore. This magnetite is found almost without exception in all placer deposits, and being the heaviest constituent of the gravel, with the exception of the gold, it usually forms the bulk of the concentrate.

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* "The New Zealand Mines Record," November 16, 1904, p. 145.

The conditions for the success of such a plant are: 1st, The process must be exceedingly cheap; 2nd, it must have a large capacity; 3rd, it must save a high percentage of gold; 4th, it must save all sizes of gold, from a few thousandths of an inch to the size of peas or larger. The necessary requirements for air separation appear to be: 1st, A free fall of the gravel through a horizontal current of air; 2nd, a blast free from all puffs; 3rd, a blast of perfectly uniform velocity throughout its entire cross section; 4th, all particles of gravel and gold must enter the blast at a uniformly low velocity; 5th, the material treated at any one time must not vary in size beyond certain limits.

XXIII.—Difficulties of Dredging.

ONE of the difficulties that beset dredging is that of dealing with a hard, rough, uneven, fissured bottom. The greater portion of the gold will often lie in the crevices of the bedrock, or in the layers of gravel in contact with it, the very action of the water resulting in the gold lodging in cracks and crevices of a rocky bottom. Such being the case, success largely depends upon whether the buckets can scoop into the upper layer of this rock, or, indeed, work at all without seriously jarring and straining the machinery. The wash-drift on the Hokitika River, opposite Kanieri Town, New Zealand, not only contained large boulders but was cemeted together to such an extent that it had to be blasted* before the dredge could lift it. Efforts had been made to force the buckets to sink a hole in the drift, but they merely revolved, skidding off the hard cement, and coming up almost empty. Where the ground is in any way tractable, a certain number of skeleton buckets with hooked steel prongs may be placed on the chain and serve to loosen the material. Buckets also, of peculiar shape, to work crevices or cracks have been invented, but the general expert opinion is unfavourable to them. It is contended that for hard and irregular bedrock operations, the suction-pump dredge is more effective than the bucket dredge. Possibly, for cleaning the actual bedrock, this may be so. But it must be remembered that before bedrock is reached several layers of auriferous material may have to be removed, and for this work, unless the material is fine, the bucket machine is undoubtedly cheaper and more efficient. Moreover, the bed-rock itself to a certain depth may contain gold, and to disintegrate and raise this, the suction dredge is powerless.

A serious difficulty also may arise, when the auriferous ground is very clayey. Such ground not only clings to the buckets and reduces their lifting and their discharging capacity, but may require puddling before it can be sluiced or passed over the tables; in this case, the costs of treatment would be increased, and the output diminished. According to F. W. Payne, the saving of gold in Otago has occasionally been difficult by the presence of clay, which in screening and on the tables collected the gold and carried it overboard. This difficulty has been largely overcome by "advance stripping," the clay being removed first, and the auriferous gravel left for the next cut. The barren clay is not treated, but delivered direct to the elevator.*

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* At Oroville, Butte County, California, hard streaks of cemented material are broken up by blasting, an ordinary 6-in. churn drill putting down holes to bed-rock every 40 ft. ahead of the dredge, each hole being charged with a canister containing 150 lbs. of No. 2 giant powder; the explosion shatters the ground without seriously disturbing the surface, and the dredge then handles it readily. The additional cost of this work is about 2½ cents. per yard. ("Gold Dredging and Prospecting," by R. H. Postlethwaite. "Mining Magazine," January 1905.)

Another and troublesome ground to treat is "cemented gravel." Where the ground is truly cemented, the proposition is hardly a dredging one; but where the term is used to designate a mass of cobbles, so packed with heavy sand as to effectually resist the action of the buckets, blasting is the most effectual method of overcoming the difficulty. Tight gravel, of this description, may be loosened by drilling, to bedrock, in advance of the dredge, lines of holes, from 50 to 100 ft. apart. The lines are separated by about 50 ft. distance, and the holes of one line divide the intervals between those in the adjacent lines. A 6-in. churn drill can be used, and tin cylinders of 30 or more pounds of nitro-glycerine, with electric fuses, serve as the explosive. The cost of such blasting is said by Mr. O. B. Finn to average about 5 cents per cubic yard. The illustrations (*see* "New Zealand Mines Record, November 16, 1904, p. 156) show the method of working with a Keystone Driller, in California. Before firing, the casing is withdrawn, but the electric wires from the fuse or fuses are carried to the surface by a supporting stick.

A trouble that long baffled the ingenuity of the dredge engineer is the presence of large quantities of black sand, as on the beaches of New Zealand. Messrs. Cutten Bros. are said to have overcome the difficulty in a dredge manufactured by them for North Beach, near Greymouth, in the following way: The material from the dredge bucket is dumped in the usual way on to a drop shoot; from this it passes into a long and narrow revolving screen, where it is thoroughly washed and the coarse material separated. The screen is perforated for about two-thirds of its length with small holes, which allow the fine material to pass through into a distributing box. This box is inclined towards the bow of the dredge. By means of a novel arrangement of doors on the distributing box the material is allowed to pass out on to tables, which are covered with miners' plush, similar to that used in streaming down boxes of ordinary dredges. The plush has an extra long nap, which is placed against the current of material. These tables are fifteen in number and 18 ins. in width, placed on each side of the dredge. Underneath those tables are return boxes, which in turn deliver the light material into a tail box, conveying the refuse into a sand sump, where it is disposed of by a

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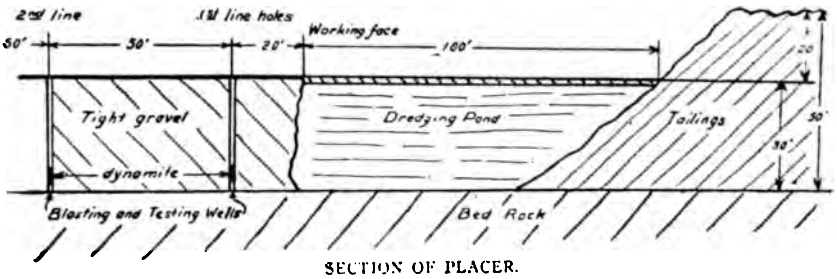
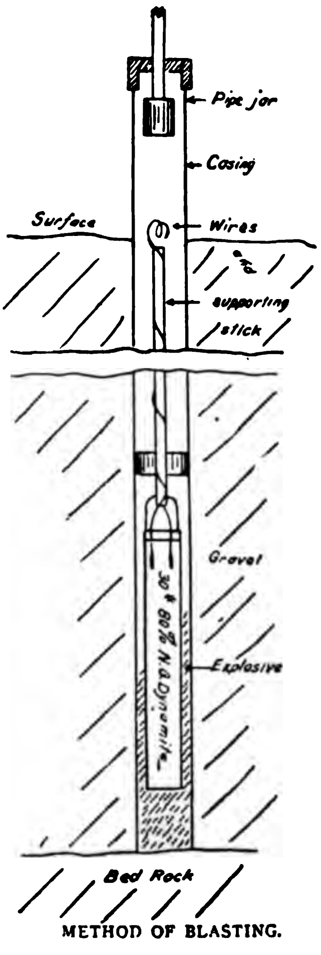
* Institution of Mining Engineers, Vol. XXIII., p. 532.



SECTION OF PLACER.



METHOD OF BLASTING.

BLASTING TIGHT PLACERS BEFORE DREDGING.

special sand elevator. The doors on the distributing box are so arranged that any table or number of tables can be shut off and cleaned up without stopping the whole work, as it done with the ordinary dredge. The concentrates collected pass into a continuously running amalgamator, where the gold is liberated and the black sands passed overboard. Until the introduction of this dredge the beach areas on the west coast have for dredging purposes been considered unprofitable, but at present nearly the whole coast has been pegged out for dredging.*

A further impediment is the occurrence of boulders, tree-stumps and the like, which are liable to catch the buckets. It is in ground largely covered with such obstacles that the grab dredge finds a most suitable place. In the removal of large boulders,† it is sometimes found practicable, after working round the stone as much as possible, to raise the ladder and let the dredge float back from the boulder. On reaching a suitable distance, the ladder is again lowered and a cavity excavated with the buckets. The dredge is then drawn forward and a grappling passed round the stone, which is dragged into the hole by moving the dredge backwards. After the removal of the boulder, the dredge is brought back into position and operations re-commenced. Explosives also are sometimes used to break up boulders into pieces manageable by the buckets. When a bucket containing a large stone reaches the deck, the machinery is stopped, and the boulder removed by hand. When such stones accumulate on the deck, they are dumped where they will not cause obstructions. In ground beset with many boulders of 3 ft. diameter and over, there has been a steady record of dredging failures, and although rich pockets may exist between the boulders, such ground is usually " turned down." Tree roots and trunks also present similar difficulties. When lying parallel to the line of advance, they can be lifted, if small enough; and if not, after excavating under and about them as much as possible, ropes or chains may be passed round, and an attempt made to drag them out. If this is ineffectual, explosives are used to burst them into manageable pieces. Trunks in any other position act as riffles, retaining gold both on the up and down sides. Modern dredges are fitted with independent means for grappling and lifting logs.

The mode of treating or removing boulders too large for the buckets, and of dealing with roots and trunks in various dredges, is thus described by the several dredging masters:—‡

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* "Improvements in Gold Dredges," "The Mining Journal," May 2, 1903, p. 516.

† Stones up to 4 ft. dimacter can be lifted by the grab hooks on the bucket chain.

‡ "Reports Relating to Minerals and Mining, New Zealand," 1899, p. 147.

Jutland Flat Dredge.—By sinking a hole alongside or near the rock (if the bottom is soft), and dropping or pushing the boulder into the excavation. By blasting, or other means, have shifted a block estimated at 40 tons. By sinking a hole for it, and pushing it in with the side of bottom tumbler. By blasting with an old boiler-tube charged, if the current is not too strong. All depends on current and possible means of sounding as to extent and size of rock, &c. Modern dredges, if intelligently handled, can shift anything.

Manorburn Dredge.—If ground permits, stones too large to lift are buried by boring a hole in bottom and pushing stone in. If working in a flat, they can often be pushed out on to face by judicious use of buckets and winches worked together.

Unity Dredge.—Clean round and leave them.

Enterprise Dredge.—Large boulders: Work up to and around same as far as possible. If working on sand or soft-clay bottom, sink into the bottom close to the boulder, so that it will settle into it; if on hard bottom, work up to it and lift ladder over it, and continue so until you get ahead, so that buckets will clear it.

Golden Terrace Dredge No. 1.—We are not troubled much with large stones. Merely lift the ladder over them and drop it again on the opposite side.

Alpine Dredge.—By using large grab hooks, which take the place of a bucket. These either take up the stones or push them to one side. Such hooks will deal with stones of not more than 4 ft. diameter.

Carrick Dredge.—Sink into the bottom alongside the stone. Then roll it in.

Buller Dredge.—Large boulders are taken off the ladder on to the deck, and are put overboard again sufficiently far from the face to clear the buckets.

Mode of dealing with Roots or Trunks of Trees.

Jutland Flat Dredge.—Though very annoying, can be shifted by stripping. Have shifted as many as eleven in a cluster, and some 4 ft. in diameter and over 60 ft. long by merely intelligent work. Roots and trees are the least trouble. Butts with roots 15 ft. in diameter, &c., can be easily enough shifted if stripped. Tackles, &c., have to be put on them, they can then be carried away from the scene of operation.

Evans Flat Dredge.—Have no large trunks of trees, the only roots being gorse roots, which the buckets can effectively deal with.

Manorburn Dredge.—If possible get under one end, and, if it will not break, it will generally be possible to bend it to surface, and then cut in sections with axes.

Golden Terrace Dredge No 1.—Very few trees met with. If stump gets jammed in the buckets, lift the ladder and fasten a rope or chain to it, and lower the ladder. Either take the stump ashore or convey to the after end of paddock and let sink.

Buller Dredge.—Cutting, blasting, dredging out, and hauling astern when practicable.

XXIV.—Selecting and Prospecting and Valuing Ground.

DREDGING ventures that court success should—

1. Select suitable ground.
2. Carefully prospect and value it.

1. Selection of Suitable Ground.

Roughly speaking, the object of search should be a deposit that has been formed by a great flow of coarse gravel, where the drainage area has been large, where the "feeders" have been good, and where the physical conditions offer no great obstacle to transport, and continuous, economical work. Specifying more in particular, the following classes of ground are favourable to successful dredge work:—

(*a.*) Wash-dirt lying on a fairly smooth, not too hard, rock bottom in rivers large enough and deep enough to float a dredge.—If the bottom is hard and rough, and the wash full of large boulders, these are unfavourable conditions, though, seeing that these conditions are favourable for arresting gold in the bed of the river, they may also lead to phenomenal success, as in the case of the Hartley and Riley dredge—a striking example of a successful dredge in a gorge-bound part of the Molyneux River.

(*b.*) Wash-dirt lying on a smooth, false bottom of clay or cement, in a river of sufficient size to carry a dredge.—On a clay bottom, a skilful winchman will clean up the wash without removing more than a mere shaving of clay.

(*c.*) Low-lying alluvial flats (and sea beaches), but little above the general water level.—In many cases these flats are worked by dredges without an elevator. If there is a great thickness of wash to be dredged, a short elevator may be needed.

(*d.*) Alluvial flats of which the surface is not more than 30 ft. above the level at which water can be kept in the dredge-pond or paddock.—With the development of the elevator, still greater heights of bank will be dealt with successfully. Tolerably high banks (40 or 50 ft.) may even now be worked for some distance back from the river. There is danger, however, that a high face may suddenly cave in, perhaps sinking the dredge and almost certainly jamming the bucket ladder.

The quest for auriferous alluvials, and, to some extent, correct judgment as to their value and their suitability for dredging purposes, is undoubtedly facilitated by a knowledge of the theory of placer formation. Omitting the comparatively few placers, formed *in situ* by the degradation of auriferous rock, the mass of gold-bearing alluvials have been deposited by the action of running waters, rivers, or streams. As Dr. T. K. Rose, in his "Metallurgy of Gold," observes, the period when a river would chiefly deposit, in concentrated amount, the gold it carried, would be when the waters were slightly overloaded, or burdened with more solid matter than they could properly hold in suspension. This favourable condition might endure only for a brief period of time, or even for only a short distance of flow. An increase of grade or a narrowing of the channel would cause an increase of current velocity, and thus one and the same stream might be underloaded in its narrow, steep sections, and overloaded in its broad, flat portions. Again, the difference of velocity between the middles and sides of a river, and between the inside and outside of a bend, might give the right condition in one section and not in another. Since the more rapid is a stream, the more and heavier material it is able to carry, it follows that the gold is more likely to accumulate where the current has been slackened, owing to a diminution of fall, or by a sudden change of direction. Where a bend is such that one side of the river is formed by a precipitous rock face, while the other side is a gentle slope, the latter is likely to serve as the resting place for the gold. The same result is effected by the presence of reefs, bars, eddies in the stream, or even by the inflow of tributaries.

The period in which a river is in condition specially suitable for deposition may recur several times, and at each period the lowest stratum laid down in that period will usually be the richest. It may happen that by some cementing material, or by an interruption of flow, an alluvial layer becomes consolidated, so as to form an apparently new bedrock, which is termed a "false bottom." As in the course of time several such bottoms may be formed, an alluvial deposit should not be abandoned as worked out, until the non-existence of further bedrock strata has been proved.

While, as already stated, slightly over-burdened rivers are in a favourable state for forming rich alluvials, those which are greatly overloaded deposit sand and mud too rapidly to admit of a concentration of gold, and the alluvials so formed are usually poorer. The conditions of the river by which the deposit has been formed can be judged from the nature of the alluvial.

As might be supposed, coarse gold and nuggets occur chiefly near the bedrock, and in arresting the gold, small depressions, creases, hollows, gutters, and fissures in the bedrock are specially useful. The nature of the bedrock, indeed, has an important bearing on the value of the deposit. Hard rock, such as granite, which wears smooth, is unfavourable; while slate is found to be one of the most favourable and richest of bedrocks, the gold easily accumulating behind the natural ripples formed by its edges. In some of the chief alluvials of Victoria, hard sandstone has proved the best bed, and in many cases the precious metal has penetrated 3 to 4 ft. into its narrow crevices. In schistose rocks, and in decomposed granites in California, gold is often found in bedrock at a depth of 1 to 5 ft. In drift mining, the bedrock is stripped to recover the gold. In hydraulicing, it is piped, or, if too hard, blasted and then piped.

As rivers and streams act as natural ground sluices, the longer the period the waters have been flowing in one channel, the more continuous and rich are likely to be the leads of gold. The tributaries acting as sluices would contribute gold, and, where they join the main system, enrichments of the deposit may be expected.

The opinion commonly held and strongly supported by experience is that gold once disintegrated from its quartz matrix is not carried far, but owes its water-worn appearance chiefly to the action of the over and by-flowing water. From this it follows that, where the river channels have run on an auriferous belt, they will contain a larger quantity of gold than where they have left the gold-bearing area: for in such portions only the light, fine gold carried by the current would be found. For the same reason, those portions of rivers and streams nearest the auriferous matrix may be expected to be richest. By locating the auriferous lode area, the inlying portions of the alluvial lead which are more likely to pay to work are also determined.

Other considerations, also, have to be borne in mind. The ancient placers are usually attributed to the action of rivers in the Pliocene period. To supply their material, an enormous bulk of auriferous rocks was worn down, the softer rocks being converted into sand or silt, and the harder fragments forming the pebbles and boulders of the drift. This explains the fact that, though the ancient drift may be rich in gold, pebbles of auriferous quartz are rare in them, for, as a rule, the seamy or honeycombed portions, or those containing decomposable minerals, such as pyrites, are, in auriferous reefs, the richest parts, while the hard, solid portions are generally poor or barren. Thus the most frangible, and, at the same time, the most richly auriferous quartz, would be easily and finely broken up, and its gold set free, while the poor, hard fragments would be rolled into pebbles or boulders. Throughout the whole process, however, it is evident that the gold, once free, did not travel far. The water-worn character does not imply motion, but rather attrition by the fragments of lighter and harder materials; and we find in the older Pliocene drifts, which may be regarded as the more highly developed examples of the results of denuding action, that, as in the case of the less exhaustively concentrated deposits of recent gullies, the gold in payable quantity lies very near the matrices from the upper denuded portions of which it was derived. Naturally, owing to the long-continued action of which the Older Pliocene drifts are the result, the gold in them has, in many places, been conveyed somewhat farther from its source, and has been distributed more equally than in the newer drifts, where the denudation was more local in action.

As time went on, it it probable that the wide channels of the Older Pliocene rivers were cut through by the newer Pliocene streams, causing, in similar manner, local redistribution, concentration, and addition of fresh material, but leaving portions unremoved. Assuming the Older Pliocene as occupying broad, shallow basins with tributary channels narrowing upwards towards the mountain watersheds, it is esay to conceive that, with the establishment of fluviatile action, the streams would naturally occupy the narrower tributary valleys, eroding them deeper, while, in the broader parts of the basins, they would cut defined channels for themselves, leaving portions of the old drifts unremoved. Thus, in what was once a broad valley, the deeper erosion of several lead channels would leave portions of the original bed standing up, in the form of low hills and spurs, covered with gravel. The Newer Pliocene leads owe their contained gold partly to local denudation of auriferous matrix during the erosion of their channels, and also, greatly to the denudations of the Older Pliocene drifts; but the richest deposits would naturally be those in leads that contained the redistributed concentrated materials of the older drifts in proximity to auriferous matrix rocks, and thus contained also the results of the further erosion of these rocks. According to the conditions of formation, therefore, we may expect to find:—

Rich lead drifts and rich adjacent Older Pliocene reef washes, or remnants thereof, when both lie along the courses of auriferous belts.

Both classes of drifts become poor, as they attain any considerable distance from such belts.

Either kind of drift, the one rich and the other poor, when one is close to, and the other some distance away from the matrix rocks.

A lead drift rich, though some distance away from the matrix rocks, when it contains the concentrated redistribution of a poor Older Pliocene drift.

A distinct class of placers are ancient glacial moraines. Such placers have peculiarities with which the hydraulic miner should be conversant. A true moraine is a pell-mell mass of *débris* containing fragments of auriferous rock just as the glacier has happened to drop them. But there has been no separation of the gold from its matrix by the action of water, nor any concentration of the grains and nuggets by the same means. Consequently, there are no rich bedrock accumulations, and the deposit will not be worth working unless the whole mass is sufficiently rich to pay. It must, however, be remembered that moraines often contain on, or in themselves bodies of water-washed material. In such cases, both separations and accumulation of the gold in certain layers may occur. Moraines, therefore, that will not pay to work as a whole, should be examined for strata of water-washed material. This can only properly be done by excavation. But such deposits, having been formed by streams flowing in the channels, are likely to be short, sinuous, hard to follow, and liable to end suddenly.

On the subject of glacial gravels as gold placers, Prof. Stone, in "Mines & Minerals," June 1900, offers many useful observations. Almost all the sediment transported by the waters of small glaciers take the form of glacial over-wash; that is, matter washed out of the sub-glacial tunnel. Near the mouth of the tunnel, this matter becomes mixed with morainal *débris*, and both transported together form a delta-like deposit across the valley or along the sides of the central tongue of ice. Thus, in a valley formerly occupied by a glacier, the drift is formed along the valley and extending up its sides: for the modern stream that succeeded the glacier has probably cut deeply into the original plain, and has made one or more terraces of erosion besides the present channel. In this channel, will be found not only much of the gold originally deposited over the plain, but also the gold that has been eroded from the banks. Thus, in general, the gravel in the bed of modern streams is richer than that towards the sides of the valley. This phenomenon of mid-channel concentration does not, however, hold in the case of the sub-glacial river. For the velocity of such a river carried the gold away from mid-channel, and deposited it at the sides, where the current was less. Nor, again, do the pot-holes of glacial streams so often contain gold as those of ordinary streams. For pot-holes being worn where an eddy forms on the bed of the stream, and stones are rolled round and round by the current, the rapidity of the glacial current rolled the stones so vigorously as to grind the gold to flour and to sweep it away. The rules, therefore, applying to a non-glacial do not apply to a glacial placer; and it is very necessary to understand the origin of a deposit it is proposed to work. Most of the gold placers of the Rockies are in glacial over-wash.

2. *Prospecting and Valuing the Ground.*

It must be remembered that the present creeks or streams which traverse alluvial gravel do not necessarily bear any relation to the original deposit. Hence it is necessary to locate the gutter or channel of the ancient stream, as well as to demonstrate the area and depth of the deposit. This may be done by shafts, by sinking air-lock cylinders, or by some form of boring apparatus. Prospecting by these means serve also to reveal the presence of large stones, boulders, quicksands, &c., the nature of the wash, the character of bedrock, and, lastly, the value of the ground. For this last purpose, the shaft is, *per se,* more reliable than the bore-hole. Since, apart from the smallness of the drill sample obtained, the action of the boring apparatus is such that gold is liable to be driven away from the drill by the current of water used in the tubular rods. On the other hand, when the sand pump is employed, the gold obtained may be largely derived from the adjacent gravel, so that it is impossible to say what volume of alluvial has supplied the gold brought up. In calculating ground values from drill samples, a factor of safety must, therefore, always be allowed. Inasmuch, however, as for the same time and money, more drill holes than shafts can be put down, it is contended that while the shaft will no doubt give a more accurate value per cubic yard of the gravel at any one spot than any one drill hole, yet the average of the time-and-money equivalent number of bore-holes will be a more accurate test for the whole ground. Shafts, it is true, will give more certain and intelligible information as to the exact kind and proportion of soil, sand, pebbles, and boulders met with, and the character of the bedrock. But such drill holes as can be put down, for, perhaps, less time and cost, will generally give as full and reliable information on these points as is necessary. The greater number of the latter also will afford better data from which to establish the contour of the bedrock and deposit than the fewer shafts.

The test by drill, says Mr. F. G. Griffin, is fully as accurate as the test by shaft, so far as the values obtained from the gravel prospected is concerned, but careful expert judgment must be used to reach an approximately accurate conclusion from the result of either drill or shaft. The reason for this is that one hole to ten acres is considered close prospecting. Therefore, if ten holes are sunk on a one hundred acre tract, and if the total value of these ten holes is divided by ten, and this result is taken for the true average value of the property, it will surely be misleading. The more holes you sink, the nearer you come to the true value of a property. My deduction from a great number of cases in actual practice is that a dredge will produce from 60 to 70 per cent. of the arithmetical average value shown by drill holes when the holes are placed approximately one to each ten acres of ground. This does not mean that the dredge will not save more than 70 per cent. of the values, but it does mean that the average value obtained from computing prospecting results as above set forth is erroneous by 30 per cent. If a property shows an average value of 20 cents per cubic yard, then a dredging property has been proved. This is true only when the drilling has been carefully done, and proper allowances have been made; further, the property must be located in an accessible place, where power is cheap.

The two factors of transportation and power must not be overlooked, and where they are high the average value of the property must be proportionately high.*

The number of holes to be put down, writes Mr. R. H. Postlethwaite, must be governed, in each case, by local conditions. If, from surface indications, it appears that the field to be prospected is the bed of a stream, contained between more or less well-defined rims, it is generally good practice to put down lines of holes to cross-cut it, the different lines being laid off some definite distance apart. Under ordinary conditions, from 500 to 600 ft. will be sufficient, the holes in the line being 100 to 200 ft. apart. If this preliminary work, which should be systematic, points to the ground having a pay channel, instead of values fairly evenly distributed, their further prospecting should be undertaken to ascertain the position and extent of this channel. But if the preliminary work indicates a basin of fairly even value, further prospecting should be laid out so as to "gridiron" the ground with holes, at definite distances, so as to get the average value of the whole field. The fallacy of laying down definite rules as to the number of holes to be drilled, in a given area, can be readily shown. Suppose, for example, that, in a given area, five holes are drilled, showing values of 15, 10, 22, 16, and 12 cents, or an average of 15 cents per yard; and, in another equal area, five holes are drilled, showing values 5, 0, 8, 7, and 55 cents, also an average of 15 cents per cubic yard. In the first case, the ground might be sufficiently prospected, but certainly not in the second, as shown by the lack of uniformity.†

Although with time and money a deposit can be more thoroughly proved by sinking prospecting shafts, driving galleries, or drifts, even this method is not free from source of error. If heavy water is encountered, it is scarcely possible to take accurate measurements of samples, since the flow of water is liable to wash out the fine sand from the sides of the working, causing the gold to become loosened from the deposit and drop to the bottom of the shaft or drift. When, however, the ground is dry or has been drained, the value of the gravel may be ascertained by careful panning.‡

The prospecting of a pond claim by shafts is thus described by Mr. C. T. Turner:—§

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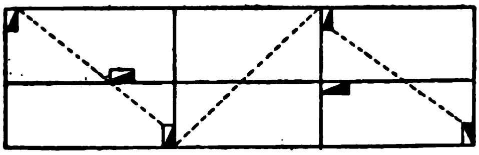
* "The Gold Dredging Industry." California Miners' Association. 1904.

† "Gold Dredging and Prospecting"; "Mining Magazine," January 1905.

‡ In testing by pan or batea, it will be convenient to remember that, if a panful of gravel weighs 20 lbs., a gold contents of 5 cents., or 2½d., per pan equals $5, or 20s. 10d. to the ton of 2,000 lbs.; similarly, gold to the value of 10 cents., or 5d., per pan shows the value of the gravel to be $10, or 41s. 8d. to the short ton, and so on. About thirty-five average gold "colours" weigh 1 gr. troy.

§ "Gold Dredging in New Zealand;" "Mining Journal," December 6, 1902.

Prospecting for a pond dredge is much more satisfactory than river prospecting. It requires a small pump and the usual impedimenta for sinking prospecting shafts. The claim is divided systematically by imaginary lines in its length and breadth, as indicated by the diagram. A field-book should be kept giving the number and situations of the shafts, together with the following particulars: (*a*) Total depth, (*b*) depth of stripping or soil, &c., (*c*) gold contents per cubic yard for each yard in depth, (*d*) proportion of fine wash to coarse wash and boulders, (*e*) condition of bottom, whether rock (live or decomposed) or clay, whether the rock carries gold in its crevices, and if soft enough to break up, (*f*) total cubic contents of each shaft, together with total weight of gold obtained from each shaft. By this system, a reliable basis is obtained, and, given proper and intelligent manipulation, an accurate estimate may be formed of value of gold to be obtained in return for a given outlay. Bores are being much used for prospecting purposes, but the information to be obtained is not so complete, although the gold returns are more likely to err on the side of the pessimists: the proportion of heavy stones to fine wash is not accurately given, so a serious error may be made in the design of the necessary plant, causing constant loss in time, money, and material. Too often the reports on dredging claims are based upon the value per cubic yard of fine wash, ignoring the fact that the boulders (often over a ton in weight) occupy space, have to be dredged, and return no gold; consequently, the prospecting returns are exaggerated, costs of working cannot be met, and the unfortunate shareholders have to suffer. Auriferous wash varies very much, not only in different fields, but in different localities in the same field. In many cases, heavy wash—that is, containing many large boulders—yields but a comparatively small quantity of gold per cubic yard, owing to the fine flaky nature of the precious metal; but this wash has the compensating advantage of carrying the gold evenly disseminated from surface to bottom, being in strong contrast to the wash that is comparatively fine, containing few stones larger than a cocoanut. In this case, the gold is more often coarse and shotty, requiring little skill to save, and is generally close to the bottom, so that a great depth of gravel has often to be dredged before the payable lead is reached. It is almost a foregone conclusion that claims with hard, rocky bottoms will retain a great portion of their gold after the dredge has passed over, owing to the difficulty of cleaning



up the bottom. Most igneous rock bottoms resist the buckets, while aqueous rocks are often soft enough to yield an inch or two, and so give up the gold. Clay or pug bottoms, with intelligent manipulation of the buckets, can be made to yield up practically the whole of the gold that may be on or above them; when the gold is once lifted, it is entirely the fault of the design and management of the dredge if it is allowed to return. In reporting on pond dredging claims, it is absolutely necessary to be assured of an ample water supply. With very clean wash, 150 cubic feet per min. might suffice; whereas, where there is much earth or clay, ten times as much would not be excessive. The cleaner the water, the more easily is the gold saved, is an axiom. Careful note should be taken of the amount and nature of the stripping, or overburden—whether earthy, argillaceous, or sandy. If there should be any considerable depth of stripping (3 ft. upwards), means should be taken for removing the same, without passing it over the gold-saving tables. Where water is available in sufficient quantities, and under 10 or 12 ft. of pressure, it is easy to break down the stripping and run it away through boxes to a point where it cannot contaminate the water. The stripping is the *bête noire* of the dredging engineer, and, if water is not available, he must exercise his ingenuity to dispose of the enemy somehow.

For many reasons, the prospecting and valuing of the ground is usually done by drilling. The form of drill used is that of the well-sinker. In its use, the bottom of the pipe should be kept in advance of the drill point, until bedrock is reached. When this is touched, the pipe must be driven into it or upon it, tight enough to shut out all the sand and water, and to allow the hole to be pumped out clean and dry. This is done by letting the drill go ahead of the pipe far enough to make a hole, into which the pipe shoe will fit. When the drill is working inside the pipe, the latter will jump at every stroke of the drill. This jumping can be felt by placing the fingers upon the top or sides of the pipe. When the jumping ceases, it is time to stop drilling and use the driving tool. The pipe generally used for this kind of work has an inside diameter of from 5 to 16 ins. Cobbles up to nearly three diameters may enter the pipe, and the drill is simply used to break them small enough to pass through the valves of the sand pump, and to loosen the sand or gravel so that the sand pump can handle it. Frequent pumping is necessary to facilitate driving the pipes and to bring up the gravel more in its original state. To make sure of getting all the gold out, it is well, after the first cleaning out, to pour in a few buckets of water, drill a few inches further, and pump out again. The last pulverised rock taken out can be panned out, and, if it shows no colours of gold, the hole may be considered clean. Sometimes the pipe will strike a seam or crevice in the bedrock, and it will be impossible to shut out the sand

and water. The only thing that can be done in such a case is to make a note of the fact, and, when the clean-up is made, if that hole shows a value which varies much from the others already recorded, the result from that hole should be discarded.

The choice between a hand, horse, or steam drill depends on local conditions. The steam drill, once set up, will put down a hole much quicker than a hand or horse drill. But the question may be, which drill can be moved, set up, and put down at the next hole quickest? The cost of drilling per foot is too variable to give an average. In favourable ground it may be 4s., in very unfavourable conditions as much as 15s. per foot. A hand-boring plant with 16-in. diameter pipes for 20 to 30 ft., will require one head borer, say, at 8s. per day, and three assistants at 6s. per day (wages in England). From 2 to 5 ft. per nine-hour day can be bored through gravel, and allowing 6s. per day for tools, the cost per foot will vary from 6s. 5d. to 16s. per foot. Lower rates hold for smaller diameter pipes. The cost of a plant such as is described would be about £150 in England. Messrs. Isler & Co., Bear Lane, Southwark, London, Messrs. Schram & Co., 110 Cannon Street, London, &c., make suitable drills for the purpose. In America, a well-known drill for prospecting is the Keystone Drill, made by the Keystone Driller Company, Beaver Falls, Pa., U.S.A. This drill is sufficiently popular to merit description. It is a percussion drill; its tools, consisting of a bit screwed into a heavy sinker-bar, are suspended from a stout cable; the cable passes over an upright ladder on a winding-drum, and the depth to which the tools can bore is limited only by the length of cable the winding-drum will carry; the winding-drum is used for winding the tools in and out of the hole only; the drilling or striking motion is imparted to the tools by rocking-beams sufficiently heavy to just balance the weight of the tools; these beams hitch by suitable means on to the cable before it reaches the winding-drum, and a 4 h.-p. engine rocks the beams and gives the required up-and-down motion to the chisels. The machine, running at a sufficient speed to impart fifty blows per minute, will give a free fall to the drilling tools of about 2 ft.; these tools weigh 8 to 10 cwts. The pump is raised and lowered in the same way as the tools, and has a separate cable and winding-drum, thus rendering it unnecessary to lose a second of time between winding out the drilling-tools and lowering the pump to lift the *débris* from the bottom of the bore. The pump is 8 ft. long, and on the suction principle, with well-fitting plunger. It is very powerful, and lifts anything, from dust, shot, and half-sovereigns to 1½-in. iron nuts and stones of 2 lb. weight. Two men only are required to keep the machine actually running, one to fire and help with the pump, and the other to overlook the chisel and keep it constantly turning when drilling, so that no two consecutive blows shall strike in the same place: this turning motion is easily imparted by means of the cable; and any change in material or strata is detected through the same source. When boring througb material that does not stand well, such as gravels or mud, it is necessary to line the bore-hole with piping; the pipes measure 7½-in. outside diameter, and are driven by fastening a clamp on to the top of the tools, and using the same as a monkey. The machinery, engine, and boiler are very compact, and are carried on and work from their own four-wheeled carriage; the 25-ft. ladder is hinged, and folds down when transport is necessary. The whole weighs about 3½ tons; this is exclusive of tools, pipes, and separate gear. The Keystone machine recently imported by the Keystone Seam Boring & Prospecting Company, of Dunedin, is capable of sinking a 6-in. hole to a depth of 500 ft., and since its arrival, a little over a year ago, has bored upwards of 2,200 ft. in Otago and Westland in gravels, and is now preparing to prospect for coal.*

The following detail description of prospecting and testing ground at Oroville by the Keystone driller is furnished by Mr. N. Booth Knox:—

Testing the Ground.—The land is first divided, according to its area, into blocks of from 5 to 10 acres, and a hole is drilled in the centre of each of these blocks.

The Keystone driller has been generally adopted in Oroville as having proved itself fully equal to this work. The driller consists of a "walking beam," operated by steam power, producing the required motion for raising and dropping the drill. In addition to this is a reel, on which is wound the rope of the sand pump used in pumping out the holes. The drill is suspended by a 2-in. diameter Manila rope, which passes under one sheave on the walking beam over another to the main drum. As the walking beam moves, the rope is alternately tightened and loosened, which raises and drops the drill. The drill itself consists of: (1) rope sockets; (2) drill stem, a piece of soft steel about 4 ins. diameter, and from 12 to 15 ft. long; (3) the bit, with a single cutting face about 5⅞ ins. long. When ground containing coarse boulders is being drilled, there is a liability of the drill becoming wedged in the hole, and, in order to prevent this, a tool called the jars is inserted between the rope socket and the stem. It is like two links of a chain, and when the bit is caught, these two links coming together with a shock jar the drill loose. The whole string of tools, socket, jars, stem, and bit weigh about 1,200 lbs.

Speed.—The driller makes about sixty 30 to 40 in. strokes per minute

Fuel.—About half a cord of oak wood is burned per day of ten hour shift.

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* "New Zealand Mines Record."

Water.—For drilling and washing the drillings about 1,000 gals. of water is used per day.

The Operation.—The land is surveyed, and the location of the drill holes staked out and marked by flags. The drill is set up over flag No. 1. A hole is shovelled out to a depth of about 2 ft., and the first length of casing is made ready. This section of casing or drive-pipe is 5⅞ ins. inside diameter, ⅜ in. thick, and about 5 ft. long. It is fitted with a wrought steel dive shoe to protect the lower end from injury. This drive shoe in made 7⅝ ins. diameter at the cutting edge, and is slightly bevelled inward. On the other end of the casing, is screwed a steel driving head to prevent the threads from being battered during driving. This casing, so mounted, is set up in the hole directly under the suspended drill and tamped around with excavated dirt. Drilling is now commenced. Water is poured in from time to time to thin out the material. After the ground below the foot of the shoe is loosened for a distance of, say, 1 ft., the casing is driven down and the loosened and thinned material removed by means of a sand pump, a hollow pipe supplied with plunger and foot valve. The driving is accomplished by striking the driving head with a couple of iron blocks clamped to the stem by means of two 1¾-in. bolts, the weight of the string of tools acting as a hammer. After driving, the driving blocks are removed. When the first length of casing is driven down to head, the driving cap is removed, a second section of casing is screwed on the first, the driving cap is replaced, and drilling resumed. When the required depth is reached, determined either by striking bedrock or passing through the pay stratum, the hole may be considered finished, and the next step is to pull up the casing. This is accomplished by removing the bit, stem, and jars, and replacing them by what is known as the pulling, or pipe jars. These consist of an iron boss fixed to the end of a rod 4½ ft. long. Above the boss is a 1-in. thick plate—the "knocking head"—provided with threads which are screwed into the sleeve of the top section of casing. The stem of boss passes through a square hole in the plate. The walking beam is set into motion, and the string of casings is raised by the boss striking against the knocking head. As each section is raised, it is unscrewed, and the knocking plate screwed on the next. If care is used in keeping the threads of the casing clean, the casings can be used for a long time. It is rarely that a casing is lost.

Treatment of Drillings.—The drillings extracted from the drill hole by means of the sand pump are discharged into a wooden trough, 12 ft. by 1 ft. by 1 ft., set on slight grade. From the trough, they are run into the riddle of a rocker, and rocked in the ordinary method adopted for washing gravel. Great care is taken to save all the extremely fine particles of gold, as upon this work depends the accuracy of the test made. It is customary to clean up results of each pumping, and to carefully note the number of countable colours obtained, and the character of the ground drilled through.*

For instance, a page of the driller's notebook taken from actual practice is as follows:—

HOLE NO. 14.

Pumping.	Colours.	Remarks.
Surface—10 ft.	1 speck.	Red soil, clay, sand and fine gravel.
10 ft.—11 ft.	22 fine colours.	Gravel starts at 10 ft.
11 ft.—12½ ft.	52 colours and fine gold.	Fine gravel.
12½ ft.—13¾ ft.	14 colours and fine gold.	Coarse gravel.
13¾ ft.—15½ ft.	4 fine colours.	Gravel softer.
15½ ft.—16½ ft.	4 fine colours.	Gravel softer.
16½ ft.—17½ ft.	8 fine colours (1 fat one).	Gravel coarse.
17½ ft.—18 ft.	7 colours and fine gold.	Gravel coarse.
18 ft.—19½ ft.	6 fine colours.	Gravel coarse.
19½ ft.—20½ ft.	8 colours, some large.	Gravel coarse.
20½ ft.—23 ft.	16 colours, some large.	Gravel coarse.
23 ft.—23½ ft.	16 fine colours.	Finer gravel.
23½ ft.—24½ ft.	21 colours and fine gold.	Finer gravel.
24½ ft.—25½ ft.	8 colours, fine gold.	Finer gravel.
25½ ft.—26½ ft.	13 colours, some large.	Finer gravel.
26½ ft.—28 ft.	6 colours and fine gold.	Finer gravel.
28 ft.—28½ ft.	5 colours, fine gold.	Fine gravel.
28½ ft.—29½ ft.	8 very fine colours.	Stopped in fine gravel.

Water Level, 21 feet.

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* Mr. R. H. Postlethwaite suggests the following log-book form:—

REPORT OF PROSPECTING.

Hole No. .... on the .... Claim

Situated ....

Date .... 19 ....

	Depth. Feet.	Colours			Formation Section.		Remarks.
		Size 1	Size 2	Size 3			
1							
2							
3							
4							
5							

Total depth drilled .... feet.

Bedrock below surface .... feet.

Water level below datum .... feet.

Value gold recovered .... cents. Fineness ....

Value per cubic yard .... cents.

Formula $V = \frac{100 \times \text{cents}}{\text{Depth}}$

Signed ... . Prospector.

The term "fine gold" is applied to such specks as are too small to be counted, but which play an important part in making up the total value of the hole. The gold from each clean-up is put in a small dish. This practice of cleaning up after each pumping (approximately after each foot of hole drilled), instead of one final clean-up, is all important in furnishing data for a cross-section map, showing occurrence of rich streaks, sandy and clay patches, fine gravel, depth of overburden, of false bedrock, and of water level. After the last clean-up, all the gold from the hole is collected by means of quicksilver forming an amalgam. This amalgam is dissolved in nitric acid, and thoroughly washed in hot water. A few drops of alcohol added to the wash water will prevent the spattering and loss of gold when the last drop of water is evaporated. The gold is annealed and carefully weighed. From this weighing, the value of the ground at this particular spot is calculated, and the result given in cents per cubic yard.

Calculating the Values is best shown by an example. The gold from, say, hole No. 14, weighed 2.22 grs.; this at 3.95 cents per grain equals 8.76 cents, the value of the gold from hole No. 14. The cubic contents of the hole is next calculated. To do this, a factor called the "pipe constant, or pipe factor," is applied. The inside diameter of casing is 5⅞ ins.; the outside diameter is 6½ ins. It is the practice of the district to use the outside diameter of the pipe as a basis for calculating its contents, the local engineers holding that it is the displacement of the pipe, and not the cubical contents that should be used. Figuring the cubic contents per ft. of pipe, with a diameter of 6½ ins., would give .23 cubic feet. In practice, it is found that .23 is much too small, giving values too high, values not borne out by subsequent dredging. Some engineers use .25 as factor. "Radford's Factor" is .27—a factor obtained by Mr. W. H. Radford, a mining engineer of wide experience in this class of work, by the following method: Mr. Radford sunk a shaft 3 ft. in diameter, using a drill hole as the centre, to a depth of 34 ft. The gold obtained from the shaft corresponded almost exactly with the gold obtained from the drill hole, when using .27 as the factor in the calculation. This factor is very important, as on it depends the value of the holes, and consequently the final value of the ground. The difference in the results obtained by using either the factor .25 or .27 is sufficient to change the value per cubic yard from net to gross—*i.e.*, a difference in some cases of 6 to 8 cents per cubic yard. Continuing the calculation: Hole No. 14 was 29½ ft. when drilling was stopped; 29½ × .27 gives 7.965 (cubic feet in the hole drilled). Now, we have the simple proportion—7.965 (cubic feet of gravel drilled) : 27 (the number of cubic feet in a cubic yard) : : 8.79 (the value of gold obtained) is to x (the value per cubic yard), whence x = 29.69 cents per cubic yard.

Calculating the Average Value per Cubic Yard.—The value of each hole in cents per cubic yard is multiplied by its depth in feet, and the sum of the products divided by the sum of the depth; the quotient is the average value in cents per cubic yard. Thus we have a block of dredging ground drilled with one hole to every 10 acres. The sum of the products obtained by multiplying each depth by its corresponding value is, say, 14.046. The sum of the depths is, say, 660 ft. Dividing the first by the second gives 21.28 cents per cubic yard = average value of this ground.

Mr. R. H. Postlethwaite gives a rather different method. His formula, which is stated to be based on large and extensive experiments, and frequently checked by experienced and successful operators, during the last three years, is:—

$$V = \frac{100 \times C}{D}$$

Where V = value per cubic yard in cents, which ought to be recoverable by dredging.
C = value, in cents, of bullion taken out of the drill hole.
D = depth of hole in feet.

The actual dredging results should correspond with the value V, provided that prospecting has been systematically and carefully done, that the bedrock is not hard and fissured, and that proper gold-saving appliances are used on the dredge. The constant "100," given above, refers only to prospect holes put down with a 6-in. drill, and sand pump (*see* "Gold Dredging and Prospecting," "Mining Magazine," January 1905, p. 14).

Cost of Drillings.—The mining expenses of a driller per day is:—

Labour—1 driller	$3.50
1 fireman	2.50
1 teamster and team	3.50
1 Chinese rockerman...	1.50
	$11.00
Wood, half cord at $6.00	3.00
Repairs, say	5.00
Drill hire...	5.00
Total expenses per day...	$24.00

Drilling about 10 ft. a day gives a cost of $2.40 a foot. Drilling contracts at Oroville are let at $2.50 per foot, and considering delays, breakdowns, repairs, road-cutting, and moving from hole to hole, this figure is reasonable enough. The number of feet drilled per day varies greatly, and depends on the character of the ground and the season. In soft ground, 20 to 30 ft. a day can be drilled, with a corresponding reduction in cost per foot. In winter and spring, when the top soil is wet and soft, the problem of moving the machine from hole to hole, and of bringing in wood and water, becomes a serious one.

Value of these Tests.—Three years' drilling, followed by subsequent dredging of the drilled tract, has proven that these tests are but fairly indicative of the values in the tract. For instance, one company, in order to prove the efficiency of these tests, drilled an acre of ground with 23 drill holes, which afterwards dredged within 95 per cent. of the calculated value. On the other hand, I have heard that a company with a recently-finished modern dredge has already dredged out about six acres, which produced 35 per cent. of the drilled values (two holes to the acre). It is unfortunate that more exact data regarding the value of these tests are not at hand. Engineers will recognise the ever-present liability of error and consequent dissatisfaction arising from all work where the value of the large is calculated up from the value of the small. So the chief value of this method of testing ground lies not so much in proving the total possible yield of a piece of ground, or its value in sight, but in indicating the presence and occurrence of the pay channels, depth of bedrock, water level, &c. It is now the custom to keep a driller well in advance of the dredge, the results of the drilled holes serving as a guide for its future movements.—(" Dredging and Valuing Dredging Ground in Oroville, California," by N. Booth Knox. " The Canadian Mining Review," October 31, 1903, p. 211 *seq.*)

Referring to Breckenridge, Colorado, Mr. W. L. Crow says: " There are two systems of prospecting commonly used in the district: Sinking bedrock shafts, and by means of churn drill holes. . . . When any considerable area is prospected, the ground is usually surveyed, and the drill holes located in straight lines and at regular intervals. Thus the system adopted by the Gold Pan Company is as follows: Parallel lines are run across the gulch at intervals of 250 ft. These lines are lettered A, B, C, &c. Points for drill holes are staked along these lines every 250 ft., and numbered 1, 2, 3, &c., and the holes are designated as A 1, A 2, B 1, B 2, &c. A plan of this survey is kept in the office, and from it a profile of the bottom of the gulch at any place can be drawn. Holes are drilled at the points staked, and wherever any wide variation in depth or in values is found to occur between adjacent holes a sufficient number of intermediate borings are made to accurately determine the boundaries of these irregularities. . . . A careful record of each hole is kept, being plotted to scale on cross-section paper. The values and character of the gravel at every depth, as well as the nature of the bedrock, are accurately recorded on the drawing. The usual force for each machine is two labourers and an engine boy. The drill is 4 or 5 ins. diameter, and a claim of 1 ft. per running hour in average ground is made. The average cost is about $3 per foot. The relative costs of prospecting shafts and of drill holes under the same conditions is estimated to bear the ratio of 4 to 1. . . . In the hydraulic elevator pits on the Swan River, it was found that the average value of the gravel raised was extremely close to that indicated by the drill borings."*

As regards appliances, a somewhat rough method of testing alluvials is thus described by Mr. H. E. Nicholls, A.R.S.M., in a Paper read before the Institution of Mining & Metallurgy in November 1904: "The writer has recently had occasion to test large alluvial flats for gold, and employed a method which, though in no way original, was so successful that a few notes on the operation may be of service to others who have similar deposits to examine. In Pahang, vast deposits of low-grade alluvials exist, and in the majority of cases the ground is too wet and sandy to permit its being sampled in the ordinary manner—*i.e.*, with shafts, so recourse has to be made to boring. The depth of the deposits varies from 12 ft. to 30 ft., and a typical section would consist of 4 ft. to 6 ft. clay, 12 ft. fine sand, with 2 ft. to 3 ins. of gravel carrying pebbles up to 6 ins. or 8 ins. in diameter. The bed-rock is usually greenstone or granite decomposed to a depth of several feet. At the first the ordinary method of boring was made use of, the ground being taken out by augurs and sand pumps, the gravel itself being broken up by means of a chisel, to the stem of which a 500-lb. block of cast iron was attached to give sufficient weight to the tool. This was found to be a slow and laborious process. After an examination of the bed-rock, which seemed to lend itself to the purpose, the following method was adopted. The pipes, which were 6 ins. in diameter, were driven into the ground, and forced some 2 ft. into the bed-rock, the actual depth depending on the consistency of the rock. The bed-rock acted as a plug to retain the gravel in the pipe, and in this way provide a true section of the ground passed through. On drawing the pipes, the sample in the pipes was scraped out, the thickness of the various layers carefully noted, and each washed separately. The actual apparatus used was very rough and ready, being made from a collection of old oil-well boring tools. To drive the pipes a 'jar' weighing about 500 lbs. was used; to this a driving clamp was fixed, the drives being given a drop of 2 ft. The tool was raised either by a lever fixed to a Sampson post or simply by a rope passing over a pulley at the top of the derrick. To draw the pipes, a wire rope was attached to a screwed cap fitting the top of the pipe, provided with a swivel ring, and a strain brought to bear on the rope by the agency of a small double-purchase hand winch, the pipes being turned by means of clamps fixed to them. No difficulty was experienced either in driving or drawing the pipes, though at first they were often lifted before being driven sufficiently deep; after a short time however, the men could judge by the sound made by the driving clamp on striking the head of the pipe when the pipe was deep enough, and rarely made the mistake of drawing too soon. Seven Chinamen were employed, and the average rate of sinking was a bore a day, at a cost of $8.50—10.0, or, roughly, 16s. English, which will compare favourably with any other method of boring. The method is, of course, only applicable when the bed-rock is of the nature above described, but under these conditions is eminently satisfactory, as it is open to none of the errors which are so liable to occur when sand pumping has to be employed; and, as far as any boring can be relied on, the results obtained in this way are quite trustworthy. The arrangement described was only a makeshift, and could easily be improved on."

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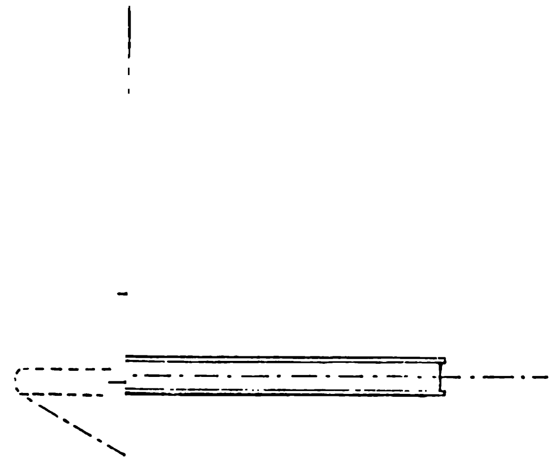
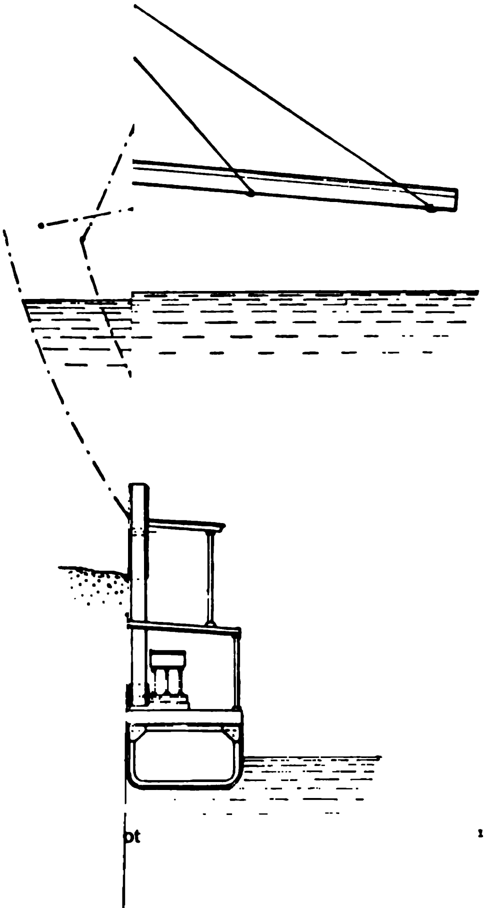
* "The Breckenridge Placer Problem." The Bulletin, School of Mines, Colorado, 1901, p. 203.

Apart from the results attained by shafts or bore-holes, there are other indications from which conclusions may be drawn. But the value of these sources of information greatly depends on the experience and training of the prospector. It is necessary to exercise caution in judging of the state of a river bed by the condition of the banks. In several places upon the Clutha, the same schists which appear hard and unyielding upon the bank have been found to be soft and pliable beneath the river. To a limited extent, however, it is justifiable to draw conclusions from the prospects yielded by the neighbouring banks, beaches, points, &c. Sometimes in seasons of drought some idea of the value may be obtained by wading and testing the bottom with a long-handled shovel. Determination, also, as to whether or no the ancient river deposits, through which the present river may have cut its channel, are auriferous, or whether local reefs, the river creeks and tributaries are gold-bearing, may justify an opinion as to the value of the river itself. Local reports, and the results obtained by neighbouring dredges, moreover, are evidence of value or the reverse. With rare exceptions, strong evidence of auriferous dredging ground is the immediate vicinity of sluicing or rocking operations. Drawing conclusions as to value from the mere colour of the gravel is likely to be erroneous. For although coloured sands, red, brown, and blue, of varying shades, often accompany gold, it by no means follows that gold always accompanies them. Nevertheless, as in the several layers of a thick auriferous alluvial, the lower strata, being nearer bedrock, are usually the richer, and as these lower layers often retain the blue tint of the unaltered ferrous sulphide of iron, it is a fact that the blue gravels of a placer are usually richer than the upper or red gravels.





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The greater richness, however, of the lower beds of an alluvial, though usual, is not invariable. Thus, in British Guiana, in such places as have been very recently formed by the disintegration of auriferous argillaceous ironstone, the dirt near the surface is much richer, and the gold purer, than near the bed-rock, here formed by the cumulative clays. As regards the upper gravels of rich placers—*débris*, dumps, &c.—the top, owing to the concentration of the gold superficially, is usually richer than the portions lying a foot or two below the surface. In general, the coarser gravels (heavier wash) are richer than the light, sandy wash.

Although in the selection and estimation of dredging grounds much guidance is afforded by sound theoretical knowledge, much by practical experience in the reading of physical indications, and much by the intelligent use of shafts or bore-holes—in fact, sufficient information to justify, in general, the inception of work—yet the most satisfactory evidence of all is the actual results of test dredging. As the Report of the Minister of Mines in British Columbia for 1896 pertinently observes: "The location of valuable pay streaks in the beds of the rivers can only be done by systematically prospecting every portion of the stream by means of a small steam dredge; after which machines of large capacity, properly designed to meet the conditions where the pay is found can be made to yield large returns, and bring this branch of mining to the front as one of the best paying propositions in the country."

The following is the specification of a prospecting gold dredge, with steel hull, designed by Mr. A. W. Robinson, Montreal. The gold-saving appliances could be amplified:—*

"The dredge will be fitted with steel buckets having a nominal capacity of 1.5 cubic feet each. The hull will be of steel, 72 ft. long, 22 ft. wide, and 4 ft. 6 ins. deep, fomed of two pontoons catamaran style. Each pontoon will be 8 ft. wide, and be connected together by steel girders placed. For shipment, the hull is subdivided according to the conditions of the case. The bucket chain is formed of steel forgings and plates. The lip plates are of a special grade of hard and tough steel 6 ins. wide and 5/8 in. thick. The pins are of manganese steel, and the pin joints are fitted with hardened steel bushings arranged to be renewable. The tumblers are of cast steel and the lighter frame itself is of steel. A steel plate hopper will receive the discharge of the buckets and conduct it into the mouth of the screen. A cylindrical revolving screen, built of perforated steel plates, will receive the material from the hopper. It is set at an inclination of 1 to 12, and will be of sufficient diameter to receive all the material that the buckets can deliver without choking.

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* "The Mining Journal," October 10, 1903, p. 398.

The upper tumbler will be driven by a steel gear from a steel pinion on the countershaft. The main gear will be 6 ft. diameter. The countershaft will have a steel pinion on one end of it which engages with the main gear and a belt pulley, 6 ft. in diameter by 14 ins. face on the other end, and it will be connected to the main engine by means of a belt. The belt thus furnishes a frictional medium for the transmission of power, so that the parts are relieved from sudden strain. A steel plate stone chute will be provided for carrying off the coarse tailings. The main engines will be of the vertical marine high-pressure type, of 32 i.-h.-p. Water for sluicing purposes will be supplied by an independent centrifugal pump, having 8-in. suction and 6-in. discharge, placed upon the main deck as indicated on drawing. The engines for driving this pump will be of the vertical high-pressure type. The pump will discharge part of its water into the head of the sluice-box and part into the head of the screen, regulated as desired. For the purpose of working the mooring lines, and for raising and lowering the bucket ladder, an independent winch will be furnished, having six drums. Each drum will be fitted with independent clutch and brake for perfect control of the various motions. The winch will also be fitted with a capstan head for general hauling and warping purposes. The winch is to be entirely of steel. All the gears will be of steel, and the frame will be built up of steel plates and channels. The two forward drums will be provided with a powerful band brake to each. The four small drums will be fitted with four standing brakes, and provided with suitable adjustment. The winch will be driven by a pair of double reversible high-pressure engines. The movements of the dredge will be controlled from the operator's platform on the upper deck on the starboard side, directly over the winch. All lever connexions for operating the winch will be placed here in convenient position, and also levers for the main engines. In this manner, the entire dredge can be operated by two men, not including those employed in fuel supply. Steam will be furnished by one boiler of the water-tube type, built for the work and adapted to burn inferior wood. The grate surface and fire-box are extra large, and the boiler is adapted for a working pressure of 200 lbs. The bucket ladder will be suspended from a steel frame by means of a wire rope tackle of ample strength. The hauling part of this tackle will be carried to the winch as before described. The suspension tackle will be of sufficient capacity and lift to raise the bucket ladder from its maximum depth to 2 ft. clear of the water. The sluice-box will be extended over the stern of the dredge as indicated on the drawing. It will be built entirely of steel, and suspended by steel wire ropes mounted on a strong Λ-frame. The sluice-box will be fitted for its entire length with steel riffles of a size and character adapted to the gold to be saved. The bottom of the screen and buckets will also be fitted with riffles. As will be seen, the dredge is manipulated entirely by wire rope anchorages, no spuds being employed. This method of mooring enables the dredge to be used conveniently in almost any situation. It can work as well in an open river with a current of six to eight miles per hour as in an enclosed pond. It can dig its own flotation through dry ground above water level, and the sluice box is high enough to dispose of the tailings without the necessity of using a tailings elevator. The dredge is said to have sufficient strength and capacity to clean up bedrock at 22 ft., and to handle free material at the rate of 60 tons per hour, and to be large enough to more than pay its working expenses if the gold exists in the ground, and, if the conditions are such as to warrant greater expenditures and large machines, they can then be entered upon with absolute assurance of success."

Lobnitz & Co., of Renfrew, Scotland, also build a prospecting dredger of the bucket type, which two men can work. In some cases, the smallest size of their regular gold dredger, suitable for running night and day, with a crew of two men per shift—say, six in all in the 24 hours—might be used for further testing ground already more or less proved. This machine will lift and properly treat per day as much gravel as 1,000 men could do with the hand rocker and washing arrangement. Besides the enormously increased amount treated, and the economical outlay in so doing, the great advantage with this type of machine is that the bucket ladder can be lowered to a greater depth below natural water level, and so reach rich beds of gravel which are quite unattainable by ordinary hand washing; and it often occurs that the richest gold, owing to its weight, is found at the deepest depths.

Whatever be the methods employed, the prospector's or tester's examination* should show the full depth of the gravel, the nature of the bed-rock, if any, and the distribution of the values; whether they are greatest at the surface, in layers or on the bottom. Values are never uniformly distributed, and nothing is more deceptive than a glib statement of so much per cubic yard. It requires the most careful judgment to arrive at a fair average value which will represent the whole. The nature of the material should also be ascertained, and this not only on the surface. The sizes and percentages of the gravel, from coarsest to finest, should be measured. This is necessary to determine the character of screens to be used, or whether any at all are necessary. The action of the gravel while being washed or sluiced should be experimentally determined. Some gravels wash very freely; others, again, are of a clayey or sticky nature, which renders them very difficult to wash. Such gravel requires very careful treatment in order to avoid loss of gold. Other deposits are of a very hard or cemented nature, often with large boulders, which increase the difficulty of working, and, if not fully provided for, failure will ensue. The condition of water supply is most important. Water is essential to the recovery of gold, and its presence in suitable quantities is a great desideratum. In dredging beds of rivers, the depth, speed of current, fluctuations of level, extent and duration of floods must all be closely observed, and their bearing on the proposed enterprise considered. In many rivers, the richest pay is found in the "bars," which are shoals or deposits of gravel brought down by the current and formed by slack water. These are frequently dry at low water, and the dredge must, therefore, be able to cut its own flotation into a dry bank. The disposition of tailings is a subject which must be carefully studied. Unless the dredge can get rid of all material passed through without choking or piling up in such a manner as to interrupt its work, it is liable to be stopped, and the entire enterprise brought to a standstill until the difficulty can be remedied. The configuration of the ground, the character of the material, the depth of the water, and the height of ground worked above water, all enter into the question, and should be carefully determined.

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* *See* "How to Make Gold Dredging Pay." By A. W. Robinson, M.Am.Soc.M.E., &c.

If the prospector is also the engineer on whose report the property is to be purchased, or "turned down," his task goes further than the work of examination. After all the foregoing points have been settled, there remains the final question: What will it cost to work the property? This is a broad question, and the answer to it is to be found only by subdividing it into all the points which affect the cost, and making a careful analysis and estimate. These points include (1) transportation, (2) cost of living and wages, (3) cost of fuel, (4) cost of lumber and other material of construction, (5) water supply, (6) character of material, (7) depth of working, (8) study of any special difficulties that may be presented. It is impossible to give any data as to these various points, or the general conclusions that may be drawn from them. Each locality will have its own characteristics which may be more or less favourable. The dredge itself will be designed to suit the conditions as they exist, and its output and operating expenses estimated. The actual output should not be estimated to be more than half the theoretical, and a liberal allowance should be made for contingencies and repairs. Under favourable conditions dredging can be done for 4 or 5 cents (2d. to 2½d.) per cubic yard, or even less, and under difficult and costly conditions the cost may rise to 20 or 30 cents (10d. to 1s. 3d.), or even more.

XXV.—The Use of Dredges.

SINCE the introduction of elevators, the field for dredging has considerably extended. The dredge is no longer confined to rivers, but can now be employed on flats, containing a large quantity of water that could not be overcome, except by heavy and costly pumping machinery; and it is not even necessary that the depth of water in such cases should be sufficient to float the scow, as by the removal of the gravel the dredge cuts for itself a channel. Preparatory to launching a dredge on ground of this description, a dam is thrown across the creek or portion of the flat, to impound sufficient water to float the pontoon. When operations begin, the buckets excavate the forward channel. Again, a dredge can be used to economically excavate a large hole or paddock in ground not suitable for dredging, but of such a nature and in such a position that the seepage can be pumped out by an hydraulic elevator, and then cleaned up in the usual way by shovelling into sluices. The use of the dredge is extended by the fact that this method of mining needs little water, as compared with that required for sluicing and elevating, and that this water can in many dry localities be obtained at small expense. Furthermore, dredges can be run by any power suitable for driving prime motors, whereas hydraulicing and elevating requires ample water power on the spot.

Some doubt exists as to possible economical dredging operations under water of torrential streams. The strong currents, frequent floods, and many loose boulders found in the channels of such streams make the working of the machines difficult and costly. But this difficulty would not be so great in the longer stretches of water, nor would it occur in the valley-like reaches in the lower portions of such streams, nor in the wide, flat portions of country where the streams enter the plains.

In the case of working flats adjoining streams subject to floods, it is advantageous to start inland rather than to operate from the river. For, even if water has to be pumped into the excavation in which the dredge is working, the cost will be small, while the advantages of being able to make your own water-level, and to secure the dredge from the dangers and detriments of floods, are very great.

The wide application of dredging is, no doubt, largely due to its freedom from one of the great difficulties of hydraulicing—the disposal of enormous masses of tailings. Again, unlike hydraulicing, it does not so greatly damage the surface of the ground. Alluvial flats that have been dredged without the use of the elevator, are merely turned over, and often admit of being at once resown. Even where an elevator has to be used, it is possible to replace the ground in a condition suitable for agriculture. To do this, the dredge should be so constructed as to strip off the top soil from each cut before dredging the auriferous subsoil. The earth, so stripped, is re-deposited over the tailings in rear, and thus the ground is restored to a state suitable for cultivation. For combined stripping and dredging purposes, the dredge may be fitted with a telescopic bucket ladder, or else with two ladders, one short and the other long, the former working on the overburden and stripping, in advance or simultaneously, while the long bucket ladder is gravel raising. In other cases, a small independent stripping plant may be preferable. Where, as is usual, the overburden is barren, this method of stripping and dredging has the additional advantage of separating the auriferous from the sterile ground, and thus enabling the former to be more efficiently treated in the gold-saving appliances. A benefit of dredging swampy flats, more especially if preceded by stripping, lies in the drainage improvements effected. The compact gravel beneath the surface is broken up, and when re-deposited its greater cubic space raises the ground surface, while its disintegrated, loose state affords improved conditions for subsoil filtration, thus improving the ground for farm purposes.

There are naturally objections to dredging. Farmers alongside of streams that are dredged, complain that while work is carried on the water becomes so turbid as to be unfit for watering cattle; and that, in flood time, such water overflowing the land deposits so much silt as to destroy the crops and injure the pasture. Then again, the bed of the river may be gradually raised by the deposition of silt, and thus the liability to floods increased. The muddy condition, too, given to water by dredging favours the growth of vegetation, which at times chokes and narrows the channel, and adds to the risks of flooding. In some cases, banks of tailings are formed in the centre of a river channel, and, checking the flow, cause the stream to scour its banks.

In the New Zealand Annual Mines Statement of 1904, the Minister, referring to flat dredging, stated: "During the early period of dredge mining on the alluvial flats of Southland, fears were freely expressed to the effect that the work of the dredges would inevitably result in the total destruction of the land. This does not appear to be the case to the extent predicted, as on some of the swamp lands which have been dredged vegetation is springing up, and is preferred by cattle to that growing on adjoining flats which have not been turned over. The planting of forest trees on land which has been dredged has also been undertaken, and present appearances are in favour of the experiment being eminently satisfactory."

The nature of the material workable by dredges is of the widest variety. On sea beaches, the wash consists chiefly of quartz and ironsand, while the gold is so fine as to be very difficult to save. The presence of much black sand impedes the saving of the gold on the tables, and, though beaches are often fairly rich, no great success has, so far, attended their dredging. It is stated that a New Zealand company has recently been formed to work a beach site on the west coast, above high-water mark, by machines mounted on wheels, and travelling on rails. The plan provides two structures, one to carry the digging and screening apparatus, together with the necessary boilers and engine, and the other to hold the gold-saving tables and appliances. The track is to be laid parallel with the coast line, and far enough back from it to permit of leaving a dyke or wall of sand between the water and the working pit. The ladder is hung so that it can swing sideways through a reach of 25 ft. on each side of a centre line, thus making it possible to excavate a trench 50 ft. wide. There will be a short and a long ladder; the former to work off the overburden down to the level of the ties under the track, and the latter to reach down to the gold-bearing stratum, which is 20 to 30 ft. lower. On the trucks following the digger, all the gold-saving appliances will be assembled, and from them the sand will be discharged sideways to the sea. The plan of operation contemplates taking off the overburden first over the entire length of the trench, and then working backwards for the pay with the long ladder, on which, of course, the buckets will have to travel up on the under side.

On some alluvial flats, the wash consists of rather fine gravel and gold, correspondingly fine. On flats of this character, the presence of clay mixed with the wash often causes the loss of much gold.* As a compensation, the cost of repairs, on account of the light ground, is small. Where a river flows through alluvials, as on the flats themselves, there is usually a false bottom of clay, well adapted for being cleaned up. Occasionally a hard but fairly smooth conglomerate bottom is met, and even at times the wash has been found to lie on a bed of lignite. In some places good wash has been found at depths of perhaps 50 to 60 ft. below the false bottom on which the dredge was working. On the Molyneux River and the adjacent flats, the wash as a rule consists of rather coarse gravel, the greater part of which will not pass the holes in the trommel. Those New Zealand dredges, working on alluvial flats, find that the best gold occurs in the coarser seams of gravel. On the river, the best wash lies along the bottom, on which the dredge works—be it clay, cement, or rock.

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* It has been stated that a loss of 2 grs. per cubic yard is a fair average when auriferous wash is overlaid by a heavy subsoil and clay. ("Mines and Minerals, New Zealand," 1900, page 41.)

An extremely good indication of gold in the wash is the presence of numerous small but heavy black pebbles, which are of sizes up to 1 in. in diameter. These pebbles, commonly called "Maori stones," are invariably strongly attracted by a magnet.*

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* Mr. P. G. Morgan, "Engineering & Mining Journal," New York, *loc. cit.*

XXVI.—Dredging Leases.

(*a.*) CLASSIFICATION.

DREDGING leases are divided into two classes—viz., river claims and so-called dry land claims, but as dredging requires water, it is preferable to call the dry land claims, pond claims.

In New Zealand, the area of claims is 100 acres, or under. The maximum area of pond claims is easily obtained. But only one mile of river is allowed to each river claim, so if the river be narrow, the claim is correspondingly small, and *vice versâ.*

It is generally admitted that river claims are more speculative than pond claims, although, when they are successful, the results are often much more remunerative than those from adjoining pond claims. This is owing, in great measure, to the clean water obtainable for washing, while pond dredging water is frequently of the consistency of pea-soup. On the other hand, the pond dredges do not lose so much time, not being affected by floods, &c. Therefore, a smaller return per cubic yard pays, where the river claims would fail.

In selecting new claims, due regard must be paid to the choosing of a site on which to build pontoons, &c. Such must be a pond or reach comparatively smooth, reasonably unaffected by floods, and of sufficient depth to float the pontoons when all the machinery is aboard. It is often necessary to build the pontoons some distance from the claims, and float them to the scene of operations when finished. Preferably, build the dredge above the claim if there is no available site on it. It is easier to float down on flood water than to pull against the stream.

(*b.*) TERMS AND CONDITIONS.*

British Columbia (Circular of October 28, 1898).

Period: 20 years, with privilege of renewal at same terms.

Area: Not more than five miles along stream.

Rental: $50 per mile per annum, minimum. (This has never been exceeded on the Fraser or Thompson Rivers.)

Working Conditions: Development work, $1,000 per mile per annum. The value of new plant and machinery employed to count as money expended.

New Zealand (Mining Act, 1898).

Period: Not limited during continuous compliance with working conditions and payment of rental. After default of payment, which is in advance, for twenty-one days, distraint and confiscation of plant (Regulation 83 (2), p. 9).

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* "Gold Dredging in British Columbia." Report, Minister of Mines, 1902.

Area: Not more than one mile along stream, nor total acreage of more than 100 acres (Sec. 76).

Rental: 1st year—2s. 6d. per acre, say, 60 cents.
2nd year—5s. per acre, say, $1.25.
After—7s. 6d. per acre, say, $1.85

Working Conditions: Holder of lease is required to work "continuously, with reasonable diligence and skill" (Sec. 85). The Warden may require that each dredging claim shall employ up to seven men for each dredge (Sec. 86, Sub-sec. 2), but, in lieu of half the number of workmen, capital may be expended instead of such employment, at the rate of £1,000, say, $5,000, for each man not employed; *see* Sub-sec. 4, Sub-sec. 1 (*d*) of Sec. 85, which provides: "The holder shall commence and prosecute the construction or acquisition of a dredge for working the claim within such time as the Warden fixes."

New South Wales (Gold and Mineral Dredging Act, 1899).

Period: Not more than 15 years (Sec. 3, Sub-sec. 4).

Area: Maximum of 100 acres (Sec. 3, Sub-sec. 2).

Rental: 20s. ($5) per acre per annum (Sec. 11, Sub-sec. 4 (*a*).

Working Conditions: Not less than seven men continuously employed on each 100 acres, which number may be increased by the Warden to ten. In lieu of such employment, an expenditure of £50, say $250, for each acre (Sec. 3, Sub-sec. 2).

Western Australia (Department of Mines, 1899).

Area: Not to exceed 5,000 acres.

Rent: 6d. per acre per annum.

Working Conditions: Within one year after granting of lease machinery to the value of £3,000 for every 2,000 acres of leases is to be employed.

Queensland (Statutes, p. 1,868).

Period: 21 years.

Area: Not exceeding 25 acres.

Rental: £1 per acre per annum.

Victoria (Statutes, 1890, p. 2,508).

Period: Not exceeding 15 years.

Area: Not limited by Statute.

Rental: 5s. per annum per acre.

British Guiana (Ordinance No. 1 of 1903, and Regulations thereunder).

Under the heading "Concessions," the regulations provide for dredging claims, prospecting areas, and unspecified special concessions by approval of the Secretary of State. Dredging concessions are limited to 500 acres; they may be granted by the Governor, and may be subject to, or include, any particular conditions deemed expedient. The fixed regulations, however, require payment of a fee of $10 (£2 1s. 8d.) on application; a deposit of estimated amount of survey, where survey is ordered; and the first year's rental of 10 cents (5d.) per acre, paid in advance. A bond is, or may be required of the concessionaire for such sums as the Government may elect to impose (normally £500) for due compliance with the terms of the concession.

Prospecting concessions of unspecified, but very large, area, are granted on leases of three years or so, at rentals of 7 cents (3½d.) per acre. The term of these concessions is provided for the examination of the area covered, on conclusion of which, ordinary mining grants are issued for such portions as may be selected.

On the whole, the mining laws of British Guiana are exceptionally generous. Some of the particulars in which they favour mine operations in unusual measure or kind, are as follows:—

(1.) The fees and rentals, except for diamond lands, are exceptionally low, being 3½d. only, as against the 10s. and 20s. annual rental per acre of the Australian Colonies. A square mile of gold mining, sluicing, or dredging ground would cost:—

In Guiana	£9 6s. 8d. to £13 6s. per annum + royalty of 2s. 11d. per oz. gross.
In W. Australia ...	£640 per annum for quartz mining, and £16 per annum for dredging + royalty of 1s. per oz. gross, with compulsory working conditions.
In S. Nigeria ...	£50 per annum + royalty 7s. 8d. per oz. net.
In New Zealand ...	£80 for first year. £160 for second year. £240 for succeeding years, with compulsory mining and labour conditions.

(2.) Under the British Guiana mining laws, tenure depends practically alone on the payment of the nominal rental charges. Only in the case of dredging concessions is any performance of mining operations stipulated.

(3.) No jumping of concessions is permitted.

(4.) The British Guiana regulations are framed in the interests of large holders. The smallest holding provided for is the 27½ acre lease; whilst the ordinary concession runs to 500 acres, and prospecting concessions may extend to hundreds of square miles.

In the following fields no special dredging regulations are in force:—

Brazil (*see* "Mining Journal," October 15, 1904, p. 376).

The Consular Agent, Mr. Cooper, under "Gold Dredging," reports: "On taking up a concession, 5,000 milreis (about £250) must be deposited, such amount to be forfeited if the company be not formed and work commenced by the time stipulated, two years generally being given to the concession. A prolongation, however, can be obtained if the delay in commencing work can be justified."

Mr. Vice-Consul Rhind, in his report, dated Rio de Janeiro, August 23, 1904, states: "It is to be regretted that, notwithstanding the general indications within and without the country of a reviving interest in mining possibilities, nothing has as yet been done in the direction of adequate mining legislation. It is, therefore, just as difficult, or impossible, now, as before, to obtain good and secure titles to mineral properties, and would-be investors are advised to be cautious in their negotiations and dealings."

British Central Africa (*see* "Mining Journal," May 14, 1904, p. 549).

The prospector is apparently free to enter on any land, provided that he undertakes to indemnify any owner for surface damage. In other respects, the law resembles that of the Transvaal. The prospector's license—obligatory where prospecting is not done by the owner on his own land—costs 5s. a month; discoveries of precious mineral must be reported, under £50 penalty, as in the Transvaal draft law. An alluvial claim is 150 ft. by 150 ft.; the discoverer's reward being four claims. Claims can be transferred or amalgamated. The Government royalty on gold is 2s. an ounce.

As prospecting areas must be worked by at least one European and two native servants during at least seven days out of every calendar month, it may be assumed that similar provision is made for mining claims should any diggings be proclaimed. It does not appear from the summary whether any regulations for dredging are included, but considering the rapid extension of this industry, and the activity displayed in the Massikessi district not far away, well-considered regulations are certainly necessary.

Orange River Colony (*see* "Mining Journal," February 27, 1904, p. 236).

In alluvials, the owner has the right to peg 100 claims, after the discoverer has taken 20 claims. On proclamation, private land is to be thrown open for pegging and Crown land sold. Every person of European descent over twenty-one, holding a claim license, may peg 50 mining or 3 alluvial claims respectively. Alluvial claims are 150 ft. square. A prospector is charged a license fee of 5s. a month; 20s. per month is the fee for an alluvial claim license. Fees may be doubled, if the holder does not work at least one claim.

Madagascar (Decree of February 20, 1902).

The mining laws of Madagascar are very liberal, and make no distinction between foreigners and Frenchmen, equal rights being granted to all Europeans and persons of similar status (*Européens ou assimilés*), irrespective of nationality.

Mining companies, however, must be constituted in accordance with French law, and have their head office either in France or Madagascar.

No permit or license is required for preliminary prospecting. When, however, a claim has been selected, it must be pegged, and intimation to this effect given immediately to the nearest administrator, with a request for a prospecting license (*permis de recherche*).

The charge for a *permis de recherche*, or prospecting permit, which is available for twelve months, is £4. At the expiration of the first year, this may be renewed for a second or third year on further payments of £8 and £20 respectively, but after the third year the holder must either abandon the claim or exchange his prospecting permit for a *permis d'exploitation*. The holder of a prospecting permit can work his claim and dispose of the proceeds on paying to the Government a duty of 10 per cent. on the value of the gold extracted.

Rhodesia (Government Notice No. 276 of November 24, 1904).

Within the reserved area (Victoria district, west of Mutirikwi or M'Telekwe River) a prospecting license entitles the owner personally to peg only one alluvial claim; every claim holder must begin work within 60 days of pegging; cessation of work for 14 days is held as abandonment of the claim, but an extension may be obtained on payment of £1 for every seven days.

A claim is 200 ft. by 200 ft.; about 700 claims go to a square mile.

For further particulars, *see* "The Mining Journal," December 24, 1904, p. 649.

Venezuela (Mining Code of April 19, 1904).

The mining concessions for alluvial gold, in whatever form, will pay 10 per cent. on the gross product of their exploitation, and further, the mining tax of two bolivares per annum per hectare, whether the surface belong to the nation or to a private owner.

Article 18.—Persons who, according to Venezuelan law, are capable of acquiring property, may obtain mining concessions, but the concessionaire, or the company which he may form, will always be considered as Venezuelan, even if all or some of its members be foreigners, and they will be subject to the jurisdiction of the tribunals of the Republic in all affairs which are caused and occur in its territory, and they may never allege, with regard to matters relating to mining concessions, any right whatever, in any form, of their being foreigners, and they will have only those rights and means of defending the same which the laws of the Republic grant to Venezuelans. In consequence, foreign diplomatic agents cannot have any interference whatever in said matters.

XXVII.—Capital Required by Dredging Companies.

As the only expense is the cost of building and erecting a suitable dredge, and, in an alluvial claim, of excavating a paddock to float the dredge, £7,000 to £10,000, or at an outside £20,000, is usually sufficient capital for a dredging company providing the promoters' demands are moderate. The cash requirements of the vendors and promoters should not exceed one-fifth of the total capital, the balance forming cash working capital. In the case of West Africa, it would require about £15,000 cash to get to work with one dredger, and probably not less than £10,000 more for each further dredger erected. From this it may be seen, first, that although dredging is suitable to small syndicates, yet there is a minimum cash capital, without which it would be a waste of money to start; and, secondly, that there is nothing to be made by taking up concessions in the hope of selling them to companies, because the industry will not bear large payments for claims or promotion.

A cheapening in the business of dredging might, in many localities, result if several companies combined to install electricity as a motive power.

XXVIII.—The Progress of the Dredging Industry.

THIS is, undoubtedly, to some extent, dependent on the compilation and publication of information and statistics obtained from actual work. It is, as the author has already remarked, difficult to obtain authentic information, and such data as are acquired are seldom sufficient to justify a general conclusion. Without offering an opinion on their accuracy, the writer would instance, as an example of the knowledge that may be furnished by the results of work carefully noted, the following conclusions formed by Mr. F. E. Young in reference to the Fraser River, British Columbia. These are published in the Report of the Minister of Mines for 1896, and Mr. Young maintains that the results of the first season's work prove:—

1. That much of the river bed contains so little gold as to be of no value for dredging.

2. Bars, which carry good pay above low-water mark, often carry little or no gold below it.

3. Coarse gold, once deposited in deep water in the bed of the river, practically never travels.

4. Pay streaks found in the bed of the river are often as sharply defined as if found in a vein of quartz. A few feet below, where good pay is obtained, not a trace of gold will be found.

5. No form of dredge yet devised can be expected to give good results under all the differing conditions found on the Fraser River.

6. Where the gold lies on bare bedrock, or but slightly covered with gravel, a suction dredge is far superior to any other form.

7. Where the gold is fine and distributed through deep bodies of gravel, a good form of dipper or bucket dredge is preferable, but the bottom should be afterwards worked over with a suction dredge to clear the bedrock.

8. Below low-water mark the gravel rarely exceeds 6 ft. in depth over the bed-rock or clay, and averages less than 2 ft.

As another instance, the characteristics of the Oroville ground, Butte County, California, are thus described by the Committee on Dredging and Jetties (California Miners' Association Manual, 1900, p. 99): "This dredging field has many peculiarities to which its great success may be accredited. First, the depth rarely exceeds 40 ft. to bedrock, and no large boulders are encountered that cannot be handled with the bucket dredge. The bedrock is a decomposed lava ash, and similar to that known in New Zealand as a 'mud flow.' The gold is distributed in many small channels throughout the ground, and scarcely an acre of the ground but gives a thoroughly good prospect. The river provides ample water for pumping into interior ground, and the writer believes that within another year the boats will be entirely away from the river and working in ponds. The great advantage of this system is that the water level can be raised or lowered as deep holes are discovered in the bedrock, and there is no trouble from freshets, which rise from time to time in the river."

XXIX.—The Future of the Dredging Industry.

Very favourable opinions on the future of the dredging industry appear from time to time in the Press. Although, perhaps, somewhat optimistic in tone, they serve to show that the industry has many staunch adherents, and that its future is undoubtedly extremely promising.

"Dredging for gold has become a mechanical and a commercial proposition; as an investment it is one of the safest in the business world. It will become more and more attractive, as the industry develops, and the returns demanded by capital so invested will not be greater than in ordinary commercial enterprises. Gold dredging is a real industry. Best of all, there has not been any promotion or inflation of dredging stock in California. There has been no 'wild cat' schemes. The industry is young, but it is clean and strong and healthy, and bids fair to grow to great proportions.

"It is useless to predict what the future has in store for gold dredging, so rapidly has the industry developed within the last two years. The improvement is steady and the field is constantly increasing. Ground is being handled to-day that two years ago was placed out of the possibility of dredges. Not only can harder, coarser deposits be handled, but the depth to which the machines can attain is constantly increasing. Under ordinary conditions, a bank 20 ft. above water level can be handled. One year ago, the greatest depth reached was 45 ft. below the water level. There are now in the course of construction on the Yuba River, near Marysville, two dredges which will dig 60 ft. below the water level. Through this development, thousands of acres of ground have been added to the dredging field, which a year ago were deemed outside the economical limits. As the development of the industry continues, I feel certain that tremendous areas of low grade ground will be rendered available for profitable dredging. Instead of the field of gold dredging becoming smaller, it is growing larger and larger each year. I remember a year or two ago it was generally considered that the Oroville district was practically the only field for larger dredging operations. To-day the proved successful dredging field extends from Alaska to Mexico. In Central America, South America, and Africa have dredging operations been started. In fact, in all countries where placer mining has been successfully carried on, the dredge is sure to follow."—("The Gold Dredging Industry." F. C. Griffin. "Mining & Scientific Press," April 16, 1904, p. 261.)

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XXX.—Fields for Gold Dredging.

THE information here given is taken from the Press, and the source cited. The author refrains from expressing any personal opinion; and, prompted by somewhat extended and varied experience, recommends the reader to seek competent advice before operating in any field of gold dredging.

Africa, East.—"Concessions for dredging operations in the navigable rivers flowing into Lake Victoria and the Indian Ocean respectively have been granted to E. von Mandelsloh and P. Wilken, both of Durban, for the purpose of extracting gold or other precious metals and diamonds from the sand."—(Mining in German Colonies, 1902—3." "Mining Journal," October 22, 1904, p. 405).

Africa, South.—"We pointed out towards the close of last year the extent to which dredging as a method of mining was extending owing to its applicability to areas worthless for any other kind of treatment. The industry continues to extend rapidly, so that besides the countries whence it has originated, there are evidences of widespread interest in other parts of the world. The most noticeable direction in which this tendency is manifested is in Africa. Besides the Gold Coast, to which several dredges have been sent, South Africa as a whole is the subject of considerable expectation. The South African Gold Dredging Company, Limited, registered in Buluwayo, is working machines in Rhodesia and Mozambique, and is proposing to instal machines in Natal and the Transvaal, if satisfactory legislation can be obtained. Not content with this, they have applied to the authorities of Madagascar, where, we understand, the whole mining law is under consideration. The company have the advice of a leading Australian expert on dredging, who is said to have great confidence in the prospects of South Africa in this branch. The company hopes to cover expenses with a recovery of 1 grain per cubic yard, though, as previous correspondence in this journal indicates, this is a somewhat sanguine estimate."—("The Mining Journal." "Extension of Dredging." October 24, 1903, p. 468.)

"An application has been made to the Commissioner of Mines for the necessary license for dredging rights over Durban Bay, and refused (says the 'Natal Mercury'). The applicant is satisfied that the Bay contains sufficient gold to make the venture pay handsomely."—("The Mining Journal," January 4, 1902, p. 16.)

During the month of November 1904, the following cables from Sir William Milton, Administrator of Southern Rhodesia to the British South Africa Company, announced the discovery of auriferous alluvials in Mashonaland:—

"An alluvial discovery in the Victoria district is well reported on by the Mining Commissioner at Victoria. It is supposed to extend over a large area. Product seen by me rough nuggety gold declared by experts equal best Klondike or Australian. The supply of water on the spot now being worked is indifferent, but it can be brought in without great difficulty, if results warrant. Average production two pennyweights rough gold to load. Largest nugget nine pennyweights. Fine gold also present, but not recovered with present appliances. The residue now being tested."

"The Mining Commissioner at Victoria reports that the area so far tested measures 800 by 300 yards. The gold is found in surface soil, which is about 4 ft. deep, and is red soil, containing diorite boulders and small pieces of quartz. Under this is talcose schist, with a little gold on top. The red soil contains good gold, the biggest nugget being 9 dwts. The Mining Commissioner at Victoria has only inspected the area now being worked, but the prospectors stated that exactly the same formation extends for miles, though, owing to lack of convenient water, they had only worked the area mentioned. The north end of the area worked is 300 yards from Fern Spruit—a tributary of the Tokwe river from the east. The soil of the intervening ground is black overlaying gravel. The prospectors sank holes reaching gravel, but they were stopped by water at 2 ft., and are hence unable to state the depth of the gravel. A sample is stated to carry fine gold. The gravel underlies the soil for a great distance along the spruit. Water comes freely in the holes, but the area now worked lies higher. The Mining Commissioner at Victoria stated that doubtless there are many other areas. Fern Spruit Valley extends for miles. Only a small portion has been prospected, but the same red soil occurs throughout, though in places without diorite boulders. Regarding water, Fern Spruit is partially an underground stream. Examination of the hills showed a gorge 60 ft. wide. A dam 15 ft. high would conserve a large amount of water. Another scheme is to bring water from the Mohagashi river, near Victoria township, twelve miles from the area worked. The river is about 300 ft. higher than the area. Supplies could be brought into Fern Spruit by a five-mile pipe, and would give practically an unlimited supply. The spruit has a well cut out channel."

The Administrator further states that the gold is large and rough, not water-worn. The information as to the average of 2 dwts. yield per load was given by an expert, and the Mining Commissioner at

Victoria now reports that the results obtained by the prospector are fully up to that figure. The prospector also tested by panning ground near Natal reef, south-west Willoughby's grant, and around Dundee mine, near Old Albany camp, close to the Tokwe river, twenty-four miles due east of Victoria township. He states first was equally good as present area, and second better, but the only proved area is that on which the prospector is now working.—(" Alluvial Gold Discovery in Rhodesia." "Mining Journal," November 26, 1904, p. 534.)

Later information points to the discovery of a further area of twenty-four square miles situated in running water. Gold also was reported on the banks of the Selati, Lelojetele, and Letaba Rivers in the Transvaal. " After the war there was a steady rush of Australians and New Zealand prospectors to South Africa. In 1902, a small party of them started fossicking Selati goldfields for alluvial deposits; eventually they reached the banks of the Selati River, south-east of Leydsdorp, and struck payable wash, and have succeeded in floating a syndicate in Johannesburg. They are now building a barge, and expect a dredger down shortly. It has been proved that the whole of the wash, which is 30 ft. in depth and in places extends 500 yards wide, running along the river for twenty miles, is auriferous, and averages upon assay from 12 grs. per cubic yard upwards. The find has now been pegged for over ten miles upon Government ground to the east. The river runs to the west into a private farm under option to the Murchison Proprietary (Transvaal), Limited, who are very busy at work there prospecting it. Also some active pegging has taken place on the Lelojetele and Letaba Rivers, and some good pannings have been washed there. The Tabina River is also held, and the claims cannot be bought; the whole proposition is a dredging one, there being plenty of water and not too swift currents. The Tabina, being rocky, will require a suction dredge; while on the others rivers grappling dredgers will work. It is considered that 4 grs. per cubic yard will cover all working expenses, and that this is a new era in the life of the Murchison Gold Fields."—(" Mining in the Transvaal." " Mining Journal," December 10, 1904, p. 589.)

Africa, West.—" The existence of extensive gold-bearing sedimentary deposits throughout the country is a well-known fact; but the prevailing supposition has been, and is, that owing to the extent upon which the alluvials have been worked the deposits have been impoverished beyond all present value; and, again, the argument is often brought forward that whereas a Chief or King working hundreds of slaves—as has undoubtedly been the case in the past—could successfully engage in the industry, the large expenditure and small returns of a company at the present time could result in nothing but failure. Any mining man who has travelled through the country and used his pan is aware of the almost universal prevalence of alluvial gold; but, even while admitting this, in a majority of instances, advances the popular argument, 'diffused over too large an area.' These generally-accepted theories and arguments are, in the main, right and reasonable. They are erroneous, however, in the exceptional instances. These exceptional instances are the beds and 'benches' of the large creeks and the rivers that for thousands of years have been the settling points for the wash and gold carried annually into them by the network of smaller streams that drain the auriferous areas. The principal and best known of these are the Volta, Prah, Offin, Birrim, Bacontra, Ankobra, Tano, and Jym, but as time and space render it impossible to deal respectively with the merits and possibilities of each in turn, I will select for a brief description the Ankobra—the one that is now most prominently before the public, and is likewise generally conceded to be the most promising of the group, draining, as it does, the richest and most extensive alluvial fields of the country.

"The head waters of the Ankobra River originate in the goldfields of Denkera (Ashanti). From thence in far-reaching curves it follows a southerly direction, passing through the districts of Sefwi, Upper and Lower Wassau, and eventually emptying itself into the sea three miles from the coast town of Axim, draining a rich auriferous and distinctly alluvial area throughout its flow. Any prospector who has prospected the creeks emptying into the Ankobra at any point throughout the distance from its source to the vicinity of its mouth, will state without hesitation that, in each and every stream that he has tested, he has found gold; not only found gold, but almost without exception found gold in every pan of gravel; and try where he may, in any stream, large or small, throughout the length and breadth of the Ankobra watershed, the result is always the same. Although these streams have been worked extensively by the natives, I do not wish to imply that they are necessarily payable from a European point of view; for in most instances, as far as testing is possible, the lower and naturally richer portions of the wash being ordinarily beyond reach, and the flatness of the country lending itself unfavourably to drainage, so far as is known, they are not. The idea, however, that I wish to convey is that all these streams, without exception, carry gold in less or greater quantities; that they drain a highly auriferous territory; and that they are tributaries of the Ankobra River. Taking into consideration these facts—that there is not a river, creek, or stream of any size whatever (and they are numbered by hundreds), emptying into the Ankobra that does not carry gold; even the 'swish' upon the banks of some of them I have repeatedly tested and invariably found to carry; that the territories drained by them have been worked for centuries, as far as water would permit, for alluvial; and, finally, that these tributaries during each rainy season become rushing torrents, discharging vast quantities of gold-bearing wash into the river,—there can be but one conclusion: that the bed of the Ankobra River is, and has been for thousands of years, the natural settling point; and, judging from any practical point of view, its wash, and especially, owing to gravitation, the lower sections and at bedrock, must contain enormous quantities of alluvial gold.

"Along the banks of the Ankobra River, extending from its headwaters to the sea, there is almost an unbroken line of native shafts, thousands upon thousands in number; but owing to the extreme flatness of the country and the superabundance of water in the deposit, the natives, with their primitive appliances, have been able to work only a small portion of the upper layers—that is, to water level. The consequence being that the naturally richer and larger sections of the deposit have lain undisturbed, since the changing of the river course. And in the instance of the river bed itself, the entire wash, excepting where high bars are exposed during the latter part of the dry season, has practically remained untouched, leaving for the dredge many square miles of solid virgin deposit. That, taken together with the benches which largely represent the old bed of the river, and can be readily worked in conjunction with the river, when not too heavily covered with over-burden, constitutes a gravel body that is well nigh inexhaustible, easily and economically worked, and that should, under anything like favourable conditions, yield the most gratifying returns.

"With a few exceptions, practically only the upper sections of the Ankobra River's wash has been tested, but, from the river's mouth for a distance of 150 miles up-stream, these investigations have always been highly satisfactory; and in the few instances where bedrock has been reached with the aid of the drill (by the Ankobra, Tarkwa, & Abbosso Gold Mining Company), the showing has been most encouraging, showing as high as 2 dwts. of gold to the cubic yard of gravel throughout the entire depth of the deposit; and borehole results are by no means a good criterion, for, owing to the vibration caused by the operation, the wash becomes loosened, and the tendency of the disturbed gold is to settle, thereby rather diminishing the returns than otherwise. There is a marked increase in the wash values toward the river source, demonstrating that in all probability the main portion of the gold originally came from the districts contiguous to its headwaters—presumably, Upper Wassau, Sefwi, and Ashanti—and this theory is further emphasised by the fact that the gold is found to be coarser the nearer these districts are approached:

the coarse gold, owing to its greater specific gravity, gravitating through the wash and finally lodging on bedrock, whereas the finer and more flakey gold is washed down stream.

"The first section of the river taken up, beginning at the sea, comprises, I understand, the exclusive dredging rights from the river's mouth to its junction with the Bonsa River, a distance, following its windings, of about sixty miles. The owners of this section of the river are very enthusiastic over their prospects, but are conservatively basing their estimates on 9 grains of gold to the cubic yard. The next section extends from the junction with the Bonsa River, twenty-six miles up-stream, to the native village of Qua Bado, and is controlled by the Ankobra, Tarkwa, & Abosso Gold Mining Company, A report on this section of the river by Mr. Montagu Barney, the well-known mining engineer, may be seen in the February 26, 1902, issue of the "Anglo-African Argus.'

"It was in this section of the river that M. Bonat, the French explorer, pursued his investigations in 1878; the results of which, though amply convincing himself and associates of the river's wealth, failed to arouse a kindred enthusiasm in Europe. One of his statements is worthy of quotation: 'There is not the least doubt of the extraordinary wealth of the rich auriferous stratum at the bottom of the river. I have been able to obtain 2 ozs. of gold from a surface hardly 2 ft. square, 12 ft. deep in the auriferous ground, and without being able to reach the bottom—*i.e.*, the true auriferous layer." Near the upper end of this section, where the Prestea road crosses the river, is located the Kantamantu Alluvial Concession; it is entirely a 'bench claim'—that is, comprising a portion of the river bank only. This concession was thoroughly opened up during last season, and I was informed by one of the officials that at one point they had opened out a 13-ft. deposit averaging 3 dwts. of gold to the cubic yard. If this is a fair sample of Ankobra bench, land dredging prospects are indeed promising.

"The next and last section of the river extends from Qua Bado, I understand, to the boundary line between Sefwi and Upper Wassau. The owners of this section have done a considerable amount of superficial prospecting, and the results of these operations generally have been very gratifying indeed. The gravel carries gold throughout, and in several instances single pans of gravel taken by two or three feet below the surface have yielded gold values of 1d., 2d., 4d., and on one occasion as high as 6d. With surface indications of this description, bedrock and the lower sections must be much better than payable. The gold is rather coarser than in the sections below, and assuming the theory of the gold having originally come from this (Upper Wassau), the Sefwi, and Ashanti districts, it should be richer; and this belief is further borne out by the statement in Mr. Barney's report to the effect that he found his values to improve as he moved up stream. This is considerably the largest section on the river, the actual dimensions of which have slipped my memory. It also comprises a 100 fathom (600 ft.) strip of beach land on either bank of, and running continuously with, the river.

"The entire territory drained by the Ankobra River is essentially an alluvial area—and particularly does this apply to that portion of the districts through which the two upper sections of the river flow. The nature of the familiar glassy white quartz (associated with every alluvial field in the world), outcropping in abundance, profusely strewn in float over the face of the country, scattered through the overburden, and constituting largely the gravel in the streams, together with the undeniable geological evidence of an extensive erosive action to which the country has at one time been subjected, unite in proclaiming it as such. Mining engineers who have visited the river, tested its wash, and conscientiously studied the conditions upon which its prospects are based, the practically illimitable gravel body, the almost total absence of boulders and clay, the comparative looseness of the deposit, the universal distribution of alluvial gold over the district, its regular occurrence in the tributaries, and the immense auriferous area drained, are unanimous in the opinion that the Ankobra River is a dredging proposition of enormous magnitude, both in extent and possibilities."—("The Future for Gold Dredging in West Africa." "The Mining Journal," November 29, 1902, p. 1,615.)

"The Ankobra is an ideal river for dredging purposes, with fine long reaches with gentle currents nowhere exceeding three miles an hour, except in the flood periods during the equatorial rains in May, Jun, and July, when the current attains a speed of from four to six miles an hour. Experience in New Zealand and California has proved that two or three grains of gold per cubic yard of wash is payable. A fair average of the Ankobra alluvial is about eight or nine grains to the yard; but much of the ground is a good deal richer. . . . The results, so far, have absolutely proved that gold in large quantities can be fairly easily recovered from both the Offin and Ankobra Rivers, and companies holding concessions on those rivers are to be congratulated upon their prospects. Neither the Offin nor the Ankobra Rivers will be worked out in this—and probably not in the next—generation. There is enough work to be done to fully employ 100 or more dredges on each river, and when it is realised that the return from a large dredge is equal to that from a 300-stamp mill, it is easily seen that, as a sound, payable proposition, dredging takes a high place."—"Gold Dredging in West Africa," by A. Arkell-Hardwick. "The African World," October 1, 1904, p. 316.)

"In its normal condition the river (Birrim, in the valley of the Atiwa and Apedwa ranges, Eastern Akim) is about 20 ft. wide and 9 ins. to 1 ft. in depth. Its bed is for miles composed of auriferous gravel, and on either bank there is an alluvial flat varying in width from 200 to 900 ft. Tests of the gravel which underlies these flats were made at a number of points along the river for a distance of between four and five miles. The gravel had a thickness of 8 to 12 ft., covered with an overburden of loam and loose clay 6 to 8 ft. thick. The average width of the flats is fully 400 ft., and the average value of the gravel throughout about 1½ dwts. per cubic yard. It is almost entirely composed of small rounded quartz pebbles, and generally rests on a soft, dark blue clay, which is occasionally replaced by the bedrock so decomposed that it is quite soft. The gold found in the gravel is coarse without being nuggety, and could be readily saved by sluicing."

"Mr. Dietzsch, in his investigations of the Birrim Valley Company's areas, sunk and tested no less than thirty-four shafts, extending at intervals over a distance of about twenty miles. These trial shafts showed an average thickness of alluvial gold-bearing gravel of 2.25 ft., with a varying width of from 200 to 900 ft., or an average of 550 ft. for a stretch of many miles. The gold values obtained carried from 3 grains to 10 dwts. to the cubic yard, while the whole series of values obtained gave an average of 1½ dwts. to the cubic yard, equal to a cash value of 5s. 3d. Assuming these estimates to be correct, a simple calculation will show the commercial values of the Birrim Valley gravels. Two and a-quarter feet thick by about 550 ft. wide by (say) 20 miles in length, equals about 4,840,000 cubic yards of auriferous alluvial ground, which, of an average value of 5s. 3d. per cubic yard, would, if successfully treated, yield no less than £1,270,500 sterling. Mr. J. H. Powell assumes that the cost of working, after the dredge is erected, would be at the rate of 4½d. per cubic yard, and, allowing £10,000 as the prime cost of each dredge erected, it can be seen what immense possibilities are opened up by the attention of mining companies being given to this method of obtaining gold in West Africa."—("The African World," October 1, 1904, p. 312a.)

About 25 miles south-east of Kumasi, the terminus of the Sekondi Railway, lies the Odumassi Concession of the Akinassi Syndicate (Ashanti) Limited. "There are several water-courses traversing the concession, which expose the talcose slates and sandstone, and in these are very extensive old native workings, none sunk to a greater depth than 30 ft., where the natives were stopped from further operations by the inrush of water. The 'wash' at that depth carried gold to the value of 1 oz. per ton, whilst in the River Owere, which seems to have been the place at which the natives panned off, pieces of quartz containing visible gold could be picked up in great number."—(*Ibid.*)

In the neighbouring Myabo Concession, the width of the native workings is about 60 yards from east to west, and the trend of the alluvial wash is north and south, and extends the full length of the concession. The wash is composed of an auriferous conglomerate. Many of the pebbles are water worn, while others are quite angular, and large blocks of quartz weighing several hundredweights are firmly embedded in the cement. The prospects obtained by rough washing gave results equal to 1 oz. of gold per ton. From the nature of the surrounding country, this is notably the bed of an ancient water-course. The valley in which this auriferous deposit is situated lies between hills of an altitude of several hundred feet, on which are several small water-courses, the rocks exposed being talcose slate.—(*Ibid.*)

Ashanti.—"The Ashanti Goldfields Auxiliary Company prospected the bed of the Ofin River with successful results, and the company has now decided to place a fleet of dredges on a stretch of ground extending over 200 miles of the river. . . . Judging from a number of photographs, the Ofin River should prove favourable for dredging, as the bed is of sandy formation, and it is claimed that there is little ground of a rough nature in the company's property."—("Gold Dredging in Ashanti and Mozambique by New Zealand Methods." "The New Zealand Mines Record," March 16, 1904, p. 337.)

"From January to April 2, three months, the dredge (of the above company) recovered, in round figures, 280 ozs., though delayed at times by the low state of the river. This gives an average of 21 ozs. per week, or an average of nearly 5 grains per yard—the cost of this being 3½ grs., showing a profit, therefore, of 3d. per cubic yard, equal to £320 for the three months. Taking these figures into consideration, it will be seen that our small capacity (18 to 20 cubic yards per hour) dredge can average a recovery of 20 ozs. to 25 ozs. per week, or a gross value of £80 to £100, with actual working cost of £60, the result being a profit of £20 to £40. We can safely calculate on an average result of from 5 to 6 grains per yard."—(Extract from the Chairman's report at the first annual general meeting, April 1, 1904.)

Australia.—"Gold dredging in Australia has not been an unqualified success, certainly nothing like what it has proved in New Zealand, although the conditions in both countries are not very dissimilar. This is largely due to the manner in which several of the leading companies have been floated for purely speculative purposes and over-capitalised. In New Zealand, no more capital than is sufficient to defray cost of plant and working expenses is asked for, consequently a dividend is declared by nearly all the companies. In several instances, more money should be spent on the dredges, especially where the river bottoms are hard. Where this has been done, the returns have speedily become more favourable. The output in New South Wales, on which the bulk of the Australian dredging work is performed, shows a steady increase, the returns during the last four years being as follows:—

	Ozs.	Value.
1900	8,882	£33,660
1901	23,585	89,628
1902	25,473	97,891
1903	27,237	104,303
Total	85,177	£325,482

The leading gold dredging operations are conducted in the Araluen district, about a couple of hundred miles south of Sydney. Here more than half the auriferous output was obtained, fourteen plants being in active operation. The total number of dredging plants in the State is forty-one, representing an estimated value of £253,480."—("The Mining World," Chicago, July 9, 1904, p. 36.)

"In the northern coastal districts of the State a party of prospectors from New Zealand have been greatly impressed with the possibilities of the beaches, which have long been known to be rich in gold, silver, and platinum, especially the Clarence and Tweed Rivers. . . . At the back of some of the beaches are vast shallow swamps, surrounded by sand hills. It is intended to dredge these swamps, the dredges, floating on 3 ft. of water, moving along the base of the sand hills, through which the black sand runs at depths varying from 16 ft. to 20 ft. Samples of the sand have been tested in Melbourne, and found rich in gold, silver, platinum, and mezalite. New Zealand dredges will be employed."—("The Mining Journal," January 7, 1905, p. 5.) (*See* Kanowna district, p. 97.)

Bolivia, South.—"Tests on the San Juan de Oro have not been made to the true bedrock; it has been definitely proved that, with the exception of about 6 ft. of shingle, overburden, &c., the upper stratum to a depth of 30 ft., is heavily gold-bearing, and that, at that depth, the false bedrock, consisting of compact mud, is reached, which we are given to understand will greatly facilitate dredging operations and enable the dredge to save the whole of the gold on the bed; in fact, these upper strata are so rich and accessible that it is doubtful whether it will ever be necessary to penetrate to the real bed at all."—("Australian Mining Standard," October 29, 1903, p. 589.)

"Having personally examined the San Juan de Oro, Mr. W. H. Cutten declares his opinion that its dredgeable area is superficially as large as the united claims in New Zealand. It is claimed that the average results of the boring tests on the Rio San Juan de Oro give a yield of from 1s. to 6s. gold per cubic yard."—(International Bureau of the American Republic, September 1904.)

"Five companies have now been floated, one in England and four in the Argentine, for the dredging of the San Juan River. Two hundred cartloads of machinery, comprising one dredge, workshop appliances, &c., have arrived on the ground, and are in the course of erection. Evidently all the companies are going to be worked under one administration, with its head-quarters in Tupiza.—("The Mining Journal," December 31, 1904, p. 677.)

Borneo.—"In Western Borneo, on the Melawi River, there is a bucket dredge working. It had just started, and the value of the ground had not been ascertained. Further up the coast from Pontianak, at Sinkawang, a pump dredge had also just started. Going into the interior from there to look at some alluvial areas, I found them too shallow for dredging, but they afford splendid chance for sluicing. . . . I went to Sambo, and, on the Tereja River, I saw a suction pump dredge. It was a failure. About £50,000 had been spent on it, and it had put about one ton of wash over the tables."—(A Correspondent to the "Engineering & Mining Journal," June 6, 1903, p. 853.)

Brazil.—"The richest existing gold mines of Brazil are in Minas Geraes. . . . But other parts of the country are known to be auriferous, and alluvial workings are met with in nearly every province. These latter are still carried on in most cases with very primitive appliances, though two companies have recently started dredging operations."—("Australian Mining Standard," January 21, 1904, p. 86.)

"A new development in gold exploration is the dredging of the River Piracicaba, a concession for which has been granted to a New Zealand Syndicate, which is now receiving the necessary apparatus from that Colony."—(Mr. Vice-Consul Rhind's Report. "Mining Journal," October 15, 1904, p. 376.)

"The dredge belonging to the Transpacific (Brazil) Mining & Exploration Company, Limited, and working on the Coxipo de Ouro River, capsised during a flood in December last. Work will not be resumed until after August. Other rivers in Matto Grosso have lately been prospected and new syndicates have been formed on the strength of the favourable reports received. There seems to be no doubt that a great many rivers in this province are rich enough to be profitably dredged, and capitalists are commencing to recognise the fact."—(Mr. Consular-Agent Cooper's Report. "Mining Journal," October 15, 1904, p. 376.)

Burmah, Lower.—In an interview with a representative of the "Mining Journal," Lieut.-Colonel K. Mackenzie Foss, F.R.G.S., stated: "Gold has, of course, long been known to exist in the Tenasserim division. . A short while ago, some prospectors were digging a well for water, and when they got down 30 ft. considerable quantities of gold were discovered. Work in the rivers could be very satisfactorily carried out by dredging for tin and gold; bucket dredges would be quite suitable. On a moderate computation, the expense of dredging would be about 4d. per cubic yard, and the resultant tin and gold should go at least 2s. a cubic yard. In some cases we have had as much as 3s. or 3s. 3d. per cubic yard."—"Would the rivers carry sufficient water for the dredging operations all the year round, Colonel Foss?"—"Certainly; in the Tenasserim River and its tributaries, there would be no question as to that. Any water difficulty is out of the question, the rainfall averaging 200 inches per annum. My own opinion," said Colonel Foss, summing up his views on the mineral prospects of Burmah, "is that this is one of the richest tin and alluvial gold districts in the world, and that its present backward condition is due to very definite reasons. Here they have the water trouble, and at a distance of 6 ft. the water comes in in such quantities that no native appliances are capable of dealing with it. Steam pumps are required. Bedrock occurs at a depth of about 20 ft. in that district, and in no single case have the natives been able to get down as deep as that, 8 ft. being about the average. The water comes in faster than the buckets are able to cope with it, and the miners are drowned out. Even if the native had the energy and capital necessary to properly exploit the country, he is not sufficiently in touch with modern resources to enable him to do so."—("The Occurrence of Tin and Gold in Lower Burmah." "Mining Journal," November 19, 1904, p. 505.)

California.—There are now twenty-seven dredges at work near Oroville, all but four of these being at a distance away from the river, some of these a mile, and some two miles. The olive and the orange orchards are giving way to the dredge, and are being rooted up bodily and destroyed, the land being found more valuable for mining than for horticulture. . . . The average dredging ground in the vicinity of Oroville yields about 27 cents per cubic yard, while the cost of mining is from 5 to 6 cents. It is quite possible that this comparatively new branch of the gold-mining industry will soon surpass, in annual results, the older branches of drift and hydraulic mining combined. It is certain that the dredging work is making a market for lands which have hitherto been worthless for almost any purpose."—(" The Engineering & Mining Journal." May 26, 1904, p. 834.)

" The sudden rise in value of the 'slickens' lands along the Yuba River, in the vicinity of Marysville, Yuba County, has been surprising. These lands are now in great request for dredging. During the many years hydraulic mining was conducted without restrictions, the *débris*, or 'slickens,' came down from the rivers by millions of cubic yards, and was deposited in many places to a depth of 30 to 50 ft. or more. Now these lands, then worth a dollar or so an acre, are worth up to $75 to $100 per acre. The gold-bearing sands extend up in the mountains to below Marysville; prospecting is being done throughout the region, and companies are being formed to dredge gold. Drillings on the river lands show that rich deposits exist below, and it is these the miners are after. . . . On the American River also, near Colfax, dredging is to be tried. For forty years or more, tailings from gravel mines were poured into this stream. . . . With heavy machinery, these deposits can be made to pay well. In addition, much of the original gravel of the river bed, which could not be reached by the old wing-dams, can be handled."—" The Engineering & Mining Journal," May 30, 1903, p. 830.)

Canada.—" The dredging problem has not yet been solved in British Columbia. The river bottoms have been proved to carry gold in quantity much greater than has been successfully worked in New Zealand and elsewhere, but the conditions—viz., boulders and swift water, combined with the fineness of the gold—have yet to be successfully overcome; here is a tempting field for invention."—(" The Canadian Mining Institute," 1902, p. 294.)

" On the Saskatchewan, gold dredging is emerging from the experimental stage, and gives promise of becoming a successful industry. Hitherto the chief difficulty has been the saving of the fine gold, but it is claimed that Mr. Hobson, the Manager of the Saskatchewan Gold Proprietary, Limited, has overcome this. Mr. McDonald, Chairman of the Universal Corporation, and a New Zealand dredging expert of some standing, claims that process of mining has centred down to one, and only one, successful method: that is, the ladder and endless chain system. Dipper dredges have been tried and found too slow; suction dredges have had their pipes cut, and the principle has been abandoned. The ladder and endless chain system has been the only one to prove successful."—(" The Canadian Mining Review," 1902, p. 59.)

" The length of the Yukon and Mackenzie Rivers in the Canadian North-West Territory, counting their branches where gold has been found, is at least twenty-thousand miles, so one can form but a faint idea of the gold that is contained in those streams."—(" The Mining Record," 1904, p. 422.)

Ceylon.—" The present general survey of the country has proved that there are practically no gravel terraces, and that the shallow deposits, which are worked by the digger in other countries, would not be sufficiently remunerative or extensive. Had there been any appreciable quantity of gold-bearing gravel in the island. it is only reasonable to suppose that during my journey of 3,041 miles, of which 1,078 miles was done on foot, that I should have found some of it. Hundreds of tests were made as I* worked from point to point; in fact, wherever gravel was found it was tested. The above refers to surface work, and the fact must not be lost sight of that we are as ignorant as ever as to what minerals occur in depth. I am, therefore, able to report upon the shallow workings, river beds, &c., as being unprofitable to work by the gold digging system. By the dredging system, I believe, if suitable places were secured, and the gold-saving appliances were modified to suit the conditions necessary for saving both gems and gold, that the undertaking, if properly managed, would pay."—(" Gold and Gems in Ceylon." " The Mining Journal," Jan 9, 1904, p. 52.)

Colorado.—The deposits of the region (Breckenridge Summit County) fall naturally into two distinct classes: those beds lying above the level of the rivers (bench diggings or high bars), and the others, consisting of the low flats and bars of the main streams. . . . this type of the deposits extends in a narrow slip on either side of the main waterways, from within a few miles of the headwaters of the Blue River to the junction of this stream with the Grand River, 50 miles north of the Breckenridge. To this area are added similar strips on several tributaries, extending back up these channels, distances varying from one-half to four miles. . . . These bars, coinciding as they do with the beds of the stream, vary considerably in width at different points. From a few hundred feet on the upper Blue River and along the tributaries, they widen out to a mile or more further down the valley. Just what proportions of this area can be classed as pay gravel, further prospecting will determine. The greater portion of it, however, at least for a distance of 15 miles north of Breckenridge, may be placed under that head. . . . Specific information concerning the thickness of the beds, at any one place, can be gotten only by a systematic prospecting of that area. . . . The Risdon dredge reached bedrock at 42 ft. on the Swan River, and this is about the average depth of all the workings along this stream, while a prospect shaft in French Gulch, sunk to bedrock, is but 26 ft. deep. The results obtained along Blue River show a similar variation. . . . In structure, the bars for the most part are low and flat, rising, except in a few instances, but a few feet above the present water level of the streams. Because of the low position of the beds, no facilities for dumping of tailings are afforded. To provide for this, necessitates the elevation of the gravel to a considerable height. To a large extent, the deposits consist of a disintegrated granite, gravel, and sand, filling the interstices between pebbles and boulders of various sizes and kinds. The presence of clay is noticeable in places. . . . Black sand also is present in small quantities. Granite, slate, and quartzite has been found to constitute the bedrock in most of the workings thus far opened. . . . Since the bedrock is quite commonly shattered and creviced, a very large amount of the gold lies well down in these cracks and seams. . . . In quality, the Breckenridge gold is quite fine, running from 820 to 900. . . . For the most part it occurs in coarse, rounded grains, 'shot gold.'"—("The Breckenridge Placer Problem," by W. L. Crow. "The Bulletin," School of Mines, Colorado, December 1901, p. 194 *seq.*)

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* Mr. G. G. Dixon, appointed by the Colonial Office to report on the quartz reefs and alluvials.

Columbia, British.—"Mr. Drummond reports that the results obtained were very satisfactory, so far as proving the value of the ground (Quesnal River) is concerned. . . ."

"These statements, both as to the value of the ground and the values recovered, made by a responsible engineer after careful tests, are remarkable, and indicate the necessity of a thorough investigation of the question of gold-saving, which, when solved, will render the Fraser a very profitable field for gold dredging. . . ."—("Gold Dredging in British Columbia." Report, Minister of Mines, 1902.)

"Taking into consideration the foregoing rather remarkable data as to the dredging grounds on the Fraser River, it might be well to draw particular attention to the terms and conditions of British Columbia dredging leases as compared with those of other colonies. The average width of the river in the vicinity of these leaseholds is 15 chains. This makes the holding 120 acres per mile of dredging lease. . . . To put it shortly, acre for acre, British Columbia is cheaper than any other of the colonies mentioned. Taking the average mile acreage as 120, it makes the British Columbia rent only 41⅔ cents per annum, while the others are: New Zealand—first year, 60 cents; second, $1.25; after, $1.85. New South Wales, $5, or more than ten times British Columbia. Queensland, the same as New South Wales; and Victoria, $1.25 per acre. The labour requirements, also, are more onerous than here." (*See* Canada.)

"In the Atlin mining division of British Columbia dredging for gold has become an important industry."—("Dredging for Gold in British Columbia." "Mining and Scientfic Press," San Francisco, November 12, 1904.)

"In this province (Atlin) there are large tracts of gravel that are known to contain values in excess of 20 cents per yard, and should other conditions, such as no very heavy wash, which cuts down the yardage per day, equal distribution of the gold, &c., obtain, then there should be numerous dredges of the modern type working in the country in the next five years, with every assurance of success. In most cases plants may be operated by electricity generated by water power, which is the most economical. . . . This season's work (at Gold Run Creek) has demonstrated several important facts: 1st, That the ground can be worked by means of dredging. 2nd, That this type (bucket) of dredge will do the work, and will take up the gold with the bedrock. 3rd, That the boulders are not an insurmountable difficulty, and can be handled in most cases. 4th, That the values in the ground are such that a dredge digging to less than one-fourth of its capacity should afford a most profitable investment."—("The Prospects for Successful Gold Dredging in the Atlin District," by H. W. Ebbs-Canavan. "The Mining Record," 1904, p. 419.)

Guatemala.—Writing from Livingston, Vice-Consul Michovsky states: "The placer mines of Las Quebradas are situated about 15 miles from the railway station 'Morales' in the foothills of the mountain range dividing Guatemala from Honduras. They were accidentally discovered about 25 years ago, and during the first ten years yielded handsome profits to native and foreign miners. When all the small watercourses were worked out, the miners left. It was then that the present owners, Messrs. Potts & Knight, of Yzabal, obtained control of it, and in their hands, with proper management, the mine soon developed into a most remarkable success. For fifteen years, it has continued to yield large profits to its owners. The richest part of the gold-bearing strata is a bluish-white gravel, sometimes clayish and hard to wash. Strictly speaking, there is no 'dead dirt' (*tierra muerta*), as even the grass soil contains gold dust. The average yield per cubic yard is about 20 c., United States currency, in the upper strata, and ⅛ to ½ oz. ($2 25 c. to $9, United States currency) in the blue gravel. The bedrock is a soft conglomerate called 'talpatete.' It is not the true bedrock, but, owing to the difficulties of getting rid of the tailings, and the adaptability of the talpatete to 'lift on' in the 'wash-up,' no one ever goes below it. The extent of the placer proper is about 2 square miles. The washing is done by the usual hydraulic process. The water is conducted to the two monitors in 10 and 12-in. pipes under pressure of 120 ft., sufficient for all purposes. No doubt gold exists in other localities of that same mountain range, but prospecting in a tropical primeval forest is something very different from prospecting in an open country like California or Australia. Covered with a dense vegetation and a thick layer of humus, the unfortunate prospector looks in vain for 'indications,' he soon gets discouraged and abandons the search."—("The Mining Journal," August 6, 1904, p. 137.)

Guiana, British.—"The history of gold working in the Guianas begins with the legendary and fabulous accounts of discoveries of the Spaniards, of Raleigh, and of the earlier Dutch. Their 'Dorado,' was variously placed: that of Raleigh and the Dutch is said to have been on Lake Amucu, on the head of the South-Western Essequibo watershed; whilst the "Laguna del Oro," of Acunha and Father Fritz, lay on the southern slopes of the same watershed, amongst the sources of the Rio Negro. Against the legendary statements and ill-founded arguments of old chroniclers, as to vast deposits in these parts, there is only known to me—through the credible statements of two or three men who have traversed some portion of these districts and washed occasional prospects—that the drifts of the Ireng and Takutu, tributary to the Branco, and those of the Rupunini, and of some higher tributaries of the Essequibo also, are auriferous, probably in payable measure, but El Dorado remains unfound. . . . In highly organised alluvial work, there have been three principal attempts—one by gold dredging on the Barima, another by hydraulic mining on the Barima, and the third by steam pump sluicing and steam dredging at Omai, on the Essequibo. . . . The value of the (Barima) deposits to be operated was proved and is unquestioned. . . . (But) the mining scheme adopted by the Georgetown company proved to be ineffective. . . . The Barima dredging operations failed because the sand and gravel drift deposits at Arakaka, where the dredging was begun, were not in any quantity, and, besides being very shallow, are associated with much clay. The Barima Dredging Company sold their dredge to the Omai Company, where it is also unsuitably placed.—("British Guiana and its Mining Development." "The Mining Journal," May 21, 1904, p. 568 *seq.*)

"The Guiana alluvial goldfields are possibly the richest existing to-day. The £6,000,000 worth of gold produced within the last two decades stands, in the main, as the result of profitable work. . . . These goldfields are, further, amongst the most extensive of the world. The payable fields already proved, cover upwards of 1,000 square miles, whilst a great part of the Colony still remains unprospected. . . . The gold-bearing so-called alluvia of Guiana have one very important and special characteristic: they are not confined to the true alluvial drifts of rivers and creeks, as in most countries, but embrace a very great extent of enriched surface and payable decomposed country rock. . . . The possibilities of discovering valuable lode forms of deposits in the process of hydraulicking off the surface residual matters, are very real and attractive. There are many other special natural advantages for mining in Guiana, against few natural disabilities. The Colony has the elements for a very large development of hydraulic mining and dredging, which should directly lead to the discovery and be accompanied by the opening of valuable lode, or lode forms, of deposits. For the successful prosecution of such operations, moderate capitalisations are wanted, with intelligent, experienced, honest, and practical direction; towards definite, clearly perceived, well chosen, and steadfastly followed purposes."—(*Ibid.*, June 11, 1904, p. 656.)

Guiana, Dutch.—"The principal creeks are: (1) Mooi Groenhurt Creek, branched by Bon Hatti Mama and Portuguese Creeks; (2) a branch of the Kapanie Creek; (3) the Molein Creek; and (4) the North Creek, with their many branches. The greater part of these creeks and their branches and banks have never before been prospected. Prospections here now made resulted in turning out 40 cents per cubic foot of ground. The formation of the creeks is: Top ground, metamorphosed diabase; sand; gravel; and top clay under the gravel, all auriferous. Reefs cross and intersect the bottom of these creeks.

"The above shows that what on this placer mine (Dieu Merci) has been done with regard to prospecting offers, not only a chance of success, but shows that the requirements of a gold mine are there to guarantee same as a paying enterprise. Wherever the pick and spade are put in the ground, from the top of the mountain right down, gold is found, and often in large deposits, even to such extent that the present working on a small scale is a paying enterprise. What, therefore, the success will be, should this claim be worked with large machinery plant, cannot be estimated. The Government railroad in projection from Paramaribo to the Lawa District, the work of which is now rapidly progressing, will, as the projection plan shows, run at the very small distance of 50 chains from the placer, so that the eventual transportation of heavy machinery will no more be any difficulty."—(Communicated by Mr. S. M. Rimbouts, M.E. "Mining Journal," July 16, 1904, p. 60.)

Guiana, Venezuelan.—"Pintas—In the environs of Caratal, the Rivers Yuruan, Cuyuni, Manteco, Cicapra, Paviche, &c., we may say that fine gold or nuggets are found everywhere. When gold is abundant enough to make washing of the soil, gravel, sand, quartz, &c., pay, the miners say that they have found a pinta. This Spanish word, meaning a stain or mark, thus indicates a spot where gold is more abundant.

" Flor.—The flor—flour—is so called because it is often more or less floury, or merely because it is found on a level with the ground —' flor de tierra.' It is a mixture of argillous sand and humus. Gold is found in the flor itself—*i.e.*, the soil—sometimes as the finest nuggets. At the present day it is not rare, after years of mining, to find gold nuggets—cochanos—or bright grains on the ground, especially after heavy rain. The layer of flor is rarely more than 3 ft. thick, and usually is some inches. The soil is dug with spade and pick, put into bags, and conveyed by asses to the neighbouring stream, where it is washed in pans. A steam dredger was employed three years ago in the Yuruari, between El Callao and Nacupay, but did not give the expected results.

" Greda.—Below the layer of tierra de flor there is often a bed of sterile clay, called greda (improperly chalk), and also caliche. It is a clay, or, rather, marl. There may be none of this greda, in which case gold is found from surface to bottom. Generally, however, the miners, after cutting through the flor, if it exists, with shafts, similar to those employed in the phosphate fields of Belgium and the Somme department, are obliged to descend to depths of 5½ to 11 yards and more before finding pay dirt. The auriferous part usually comprises the lower part of the greda, and varies from 10 to 16 or 22 yards, and has its maximum richness at the base—*i.e.*, at point of contact of the alluvion and bedrock. The common idea in Guiana, that the richest part of the greda is near a water level, is explained by the fact that this water is near bedrock. This last is composed of some of the primitive rocks we have described, the most common being the Cascajo or Piedra Azul, always more or less decomposed, and sometimes in form of compact or schistoid clay. The greda is treated just like the flor, except that it is steeped for twenty-four to twenty-eight hours in a water tank. Flor and greda, then, are the two forms of the Guiana alluvions. To them we must add the sands and gravels of the river beds, which always contain fine gold and nuggets. It would be very difficult to give an average richness for the alluvions, but we may, setting aside the value, often met with, of several thousands of francs per cubic metre, take the following figures, which come near the mark: Two miners extract, screen, carry away, and wash a maximum of ½ cubic metre, or about 17 cubic ft., of pinta earth in eight hours, and their average profit is rarely less than 7s. each. This gives us about 26s. per cubic metre. Certainly, this result is exceeded in practice, and we quite believe that the average is £2 per cubic metre (35.31 cubic ft.) in the pintas of Caratal and Cicapra.

"Canteras.—There is a circumstance which in most cases greatly increases richness of the greda, at least, when its deposit has a particular form—viz., the existence in the clay of veins or veinlets, often harder than the greda, and sometimes composed of greda, but in most cases rotten quartz. Cantera is the name given to the vein, and the gold—oro de cantera—gains a premium on the market. . . .

"We have used the word 'alluvions' to designate deposits which really are not alluvial. Strictly, this word should be reserved for the true placers formed by a current of water, which occupied or occupies the thalweg. These placers exist along the streams of Guiana, on the banks of the Mocupia, Yuruari, Cicapra, Avechica, Cuyuni, Yuruan, &c., but as regards the veined gredas of the canteras, situated, 22 to 33 yards in height, on the sides of the valleys of Campanero, or the Montana de Caiman, near Arbolito, or, again, on the hills of Laguniba and Union—viz., much above probable high water of the streams—we must abandon the word 'alluvion.'"—("The Gold Deposits of Misiones." By M. N. Paquet. "The Mining Journal," September 24, 1904, p. 304.)

Indies, East and West (Dutch).—"Our East Indies (Borneo, Sumatra, Celebes) are not very rich for dredging purposes; but special attention is being paid to the West Indies (Surinam), where the Werf Conrad Co., Limited, introduced the first gold dredgers, and where the river-beds show a rich gravel, and easy work."—(Letter from Mr. P. R. Goedkoop, February 2, 1905.)

Ireland.—"Though so far as is yet known no other auriferous deposits of economic value than the Ovoca gravels occur in Ireland, the presence of gold has been detected in various places, both in veins and alluvial sands."—("Gold in Great Britain and Ireland." J. M. Maclaren. "Trans. Inst. of Mining Engineers," Vol. XXV., Part 4, p. 455 *seq.*)

Korea.—"The greater number of the gold veins and placer veins are situated in the northern part of the Korean peninsular. The land rises from the sea to heights of 3,000 and 4,000 ft., and is deeply channelled by water-courses. These have made precipitous hills and broad, flat, river beds. . . . The placer mines are in the modern river beds. They are washed by the most simple methods of excavation, and the gold is obtained by panning the richer portions of the deposit. The dredging system is sometimes followed, the dredge being a wooden bucket attached to a well sweep arm, which is operated by manual labour."—("Gold Mining in Korea," by H. C. Perkins. "The Engineering & Mining Journal," April 7, 1904, p. 554.)

Liberia.—" So far, although Liberia has been examined in several directions by expeditions of the Chartered Company and of the Consolidated Gold Fields, there has been no discovery of importance regarding minerals. The Mandingos of the interior exhibit gold ornaments and talk about alluvial gold, but they have not hitherto succeeded in directing Americo-Liberians or Europeans to the sources of their gold supply."—(" The Republic of Liberia." " The African World," October 1, 1904, p. 320.)

Madagascar.—" Discoveries of gold deposits continue to increase, and the number of claims staked out, and licenses issued, augments each quarter-year. Some of them have commenced to pay well merely by treating alluvial deposits. . . . In a single claim, which M. de Floris commenced to work last year, he has already obtained 250 kilogrammes (4 cwts. 103.2 lbs.) of gold, and the yield increases every month; at present it is 35 kilogrammes, or 77.1 lbs. avoirdupois per month. He employs 2,000 to 2,500 miners."—(" Gold in Madagascar." " The Mining Journal," November 12, 1904, p. 484.)

Malay Peninsula.—" In Kelantan, in the Malay Peninsula, the Duff Development Company has one prospecting dredger at work. This has run, up to the present, twenty weeks, during which time it has recovered 336 ozs. of gold, at a working cost of £670 and a profit of £630. A larger dredge has been sent out, and will be at work next year. The gravel on this property has, up to the present, averaged 3 grains per yard, but the working conditions seem fairly easy."—(" The Mining Journal." " Gold Dredging." November 14, 1903, p. 553.)

" The auriferous alluvium (in Pahang) nearly always contains a certain amount of cassiterite. At Bentong the deposit is worked for tin, and the amount of gold separated has not been large. In other places—*e.g.*, Sepan—there is only a trace of tin, or none at all, with the gold. Near Kuala Lipis, also in the Anak S. Kerpan, small quantities of tin were found with alluvial gold. On the top of limestone outcrops, alluvial gold has been worked. At Tui the late Mr. Swan worked such a deposit; and at Goa a mass of iron oxide nodules and alluvial gold rests on the surface of a limestone outcrop in padi-fields. The origin of the gold at the latter locality is not quite clear. It may have come from gold-bearing veins of calcite or quartz in the now dissolved limestone, similar to the veins found at Tui; or it may have come from leaders in the argillaceous rocks which appear not far from the limestone hill. The auriferous deposits which I have called ' hill deposits ' are analogous to certain tin deposits in the Western States from which the tin is extracted by hydraulicking. I use the term because it indicates their most important feature, their occurrence on the sides of hills. They are more generally known as 'wash.' They are quite distinct from alluvium. One such deposit has been worked for gold at South Kalampong, Punjom. They have not been found to be of great importance in Pahang."—(" A preliminary Report on the Gold Mines of the Federated Malay States." "The Mining Journal," August 20, 1904, p. 187.)

Manica.—" So far as prospects go, the work done and the changes effected during the last season have proved the value and resources of the Manica alluvial deposits. Waiving at present the question of concessions which a recent proclamation apparently renders untenable, the ground which Mr. W. Marley has secured for his company, the Mazoe Luenha Gold Dredging Company, on the Luenha River, holds out considerable promise. Fine samples brought from the ground, and favourably confirmed by a professional expert, repeat, in yet one more case, the wide diffusion of gold on these fields. In the case of this property, the Zambesi River gives it facilities in cheapness of transport, the dredgers being easily towed up the Zambesi to the place of work. The Mozambique-Mazoe Gold Dredging Company, Limited, and the British African Gold Dredging Company Limited have secured the services of Messrs. Ronaldson and McCallum. Both gentlemen are well-known experts, and, in their work on the Revue Valley, have corroborated the results independently arrived at by Captain Andrade, the assay value being an everage value of 1 dwt. per cubic yard of ground. In the Muza, between the falls and its junction with the Chimezi, prospecting work has been conducted by Messrs. Hedley and Moppat; here, again, the general character of the pannings being confirmed. The gold at this place is finer than that of the Winifred, but the average is sufficient to pay for the removal of the barren overburden. It is interesting to note that at this place old workings are to be seen, left by the Portuguese miners of the sixteenth and seventeenth centuries; an old fort also being still seen, with bastions and loopholes, and places for the installation of guns. The fort, considering its age, is fairly well preserved. The property belongs to the Rhodesian Exploration Development Co., which is working on a considerable scale in prospecting the Revue Valley above the Winifred Blocks. A large number of boys are at the works, which is under the supervision of Mr. Rogers, Mining Engineer. Mr. Blake, a well-known mining authority in South Africa, has been prospecting on the Busi and the Sabi for alluvial, in conjunction with the Natal Dredging Company. Lastly, the work done by the Companhia Portuguesa de Minas d'Ouro, under the able supervision of its manager, Mr. Pimentel Pinto, has advanced the character of this property, which was taken on option by M. Dumat, who secured the services of an able New

Zealand expert, in the person of Mr. Sale. After sinking shafts, and washing tons of gravel, the results obtained were such that the property was bought for £6,000 cash plus 15 per cent. of the shares to be issued, the property being secured by M. Dumat for flotation on the Rand. For this part of South Africa, this is in the nature of a record, as the area covered comprises only 156 hectares of alluvial. Thirty months have now only elapsed since Captain Andrade took the lead, by starting work on the alluvial deposits of the district, demonstrating their value, and carrying out the spirit of the report made by the late Mr. McAdam, Chemist to the Mines Office. Since that period, money has, in a few cases, been expended on purely tentative work, which has been more than justified by the knowledge gained. The compaies already formed, and those in process of formation, will work under the concessions granted by Captain Andrade to Messrs. Macdonald, Brown, Pimentel Pinto, and Marley. The companies formed, with those to be formed, should infuse new life and hope to what at one time threatened to be a neglected district."—" Macequece Mining News."—(" The Mining Journal," January 24, 1903, p. 103.)

Mexico, Republic of.—" Gold nuggets up to the weight of 6 ozs. have been found in some of the streams of Eastern Sinaloa after the late torrential rains. Many of these arroyos have been worked spasdomically for gold for more than a century, but the lack of water at one season of the year and the floods at another have made operations difficult."—(" South American Review," November 1904, p. 224.)

Mozambique.—" A dispatch has been received at the Foreign Office from the Acting British Consul at Beira forwarding a report on gold dredging in the territories of the Mozambique Company, which, he says, is at present showing signs of assuming considerable importance in the future. This report states that for several years past the system of obtaining gold by the process known as 'dredging' has attracted attention in those territories, and, at the present time, a considerable amount of capital is being employed in importing the necessary plant and machinery. Several of the rivers, and, indeed, some of the small streams such as the Urema, Muza, and Munene, have been found suitable for this class of work, and, although it is as yet difficult to say whether the industry is destined to become an important one, it is felt that it commences with excellent prospects of success. . . . At the conclusion of his report, H.M. Consul writes: 'So far it is of course premature to forecast the future of this branch of the mining industry in these territories, but there can be little doubt that it is destined to play an important part in the future development of the mineral resources of the country.' The complete report which contains a description of the dredge in use on the Muza River, may be seen by those interested on application at the Commercial Intelligence Branch of the Board of Trade, 50 Parliament Street, S.W., any day between the hours of 10 a.m. and 5 p.m. (Saturdays, 10 a.m. to 1 p.m.)."—("The Mining Journal." "The Gold Dredging Industry of Mozambique." September 26, 1903, p. 361.)

New South Wales.—"There is room for considerable improvement in the New South Wales gold dredging industry. The extent to which it can be remuneratively conducted has yet to become definitely ascertained, it being contended by some that the uneven nature of the slate bottom of several of the rivers would prevent the buckets from recovering the gold lying in the crevices. In New Zealand, the bottoms of the leading rivers are more suitable for dredging purposes, than are many of those in New South Wales. It is doubtful, however, whether the industry will prove of a permanent character, as all the rivers which drain auriferous country have been taken up on lease, and must become largely denuded within the next few years. The quantity of gold obtained during the four years 1900—1903 was 85,177 ozs., value £325,482, each succeeding year showing an increase, which will probably be maintained during 1904. Some of the returns are at present encouraging."—("Mining in New South Wales." "The Mining Journal," September 24, 1904, p. 304.)

"The gold dredging industry is making good progress in Victoria, the total quantity of material treated in 1903 being 7,963,927 cubic yards, as against 6,911,697 cubic yards during the previous year. The gold obtained was 42,066 ozs., an increase of 8,937 ozs. on the year. There was also a slight increase in the quantity of gold obtained from each cubic yard. The number of dredging plants in operation was fifty-one, in addition to fourteen hydraulic sluicing by gravitation plants, the number of men employed being 1,100. Previous to 1900, the total quantity of gold obtained by dredging was 90,528 ozs., but since then 126,287 ozs. have been recovered, the total value up to the end of 1903 being £886,368, the dividends during the last four years amounting to £37,508. In addition, 91 tons 11 cwts. of tin have been obtained. The successful development of the industry is largely due to the fact that none of the public companies have been over-capitalised, and that each dredge is constructed to meet the requirements of the locality in which it is worked. In New South Wales, the leading difficulty has been the question of water rights and also that of the disposal of the silt, while, in more than one instance, the dredges have not been exactly of the kind required. Moreover, not a few of the auriferous streams are incapable of being safely navigated by even the smallest row boats."—(" Australian Mining Notes." "The Mining Journal," August 13, 1904, p. 156.)

"The dredging industry is progressing slowly but steadily in some parts of New South Wales, notably in the Araluen Valley. On this field, there are at the present time nine dredges in full working order, and with one exception all averaging good returns. . . . The drawback to dredging on the Araluen Flat is the lack of water, especially in summer, when the stream is practically dry. The wash is also very tight. When the Shoalhaven River proved practically worthless as a dredging field, the Araluen field provided an outlet for the several dredges on that river. . . . The dredges on the Macquarie River are getting fair returns, but the ground is tight and hard to work. Expectations were not realised in connexion with dredging operations on the Fish and Clarence Rivers."—(" New Zealand Mines Record," November 16, 1904, p. 141.)

New Zealand.—This dredging field is too well known to need further comment. The state of the industry is progressively portrayed by such monthly gold dredging returns as, for instance, are published in the "New Zealand Mines Record." Of these the following are partial examples:—

Gold Dredging Returns, 1904.

For the month of January:—

	Ozs.	dwts.	grs.
Total, Otago and Southland (66 dredges)	5,353	0	2
Total, West Coast (28 dredges)	2,046	18	0
Grand total (94 dredges)	7,399	18	2
Average yield per dredge (approximate) ...	78	15	0
Average time worked per dredge... ...	3 weeks.		

For the month of February:—

	Ozs.	dwts.	grs.
Total, Otago and Southland (70 dredges)	9,506	18	4
Total, West Coast (30 dredges)	2,626	9	0
Grand total (100 dredges)	12,133	7	4
Average yield per dredge (approximate) ...	121	6	0
Average time worked per dredge... ...	3 weeks.		

For the month of September:—

	Ozs.	dwts.	grs.
Total, Otago and Southland (71 dredges)	7,350	13	16
Total, West Coast (27 dredges)	2,077	4	0
Grand total (98 dredges)	9,427	17	16
Average yield per dredge (approximate) ...	96	4	0
Average time worked per dredge	3 weeks.		

Gold Dredging Dividends, 1904.

For the month of January:—

Name of Company.	No. of Dividends.	Amount per Share.	Total.
Earnscleugh	—	0 1 0	550 0 0
New Roxburgh Jubilee ...	10	0 1 0	375 0 0
No Town Creek*	16	0 1 0	600 0 0
Waikaka	6	0 1 0	325 0 0
Waikaka Queen	1	0 1 0	335 10 0
Total			£2,185 10 0

* West Coast dredges.

For the month of February:—

Name of Company.	No. of Dividends.	Amount per Share.	Total.
Blackwater River*	4	0 1 0	473 15 0
Callaghan's Creek*	5	0 0 6	312 10 0
Clyde	32	0 1 6	450 0 0
Charlton Creek	20	0 1 0	250 0 0
Earnscleugh	20	0 1 0	550 0 0
Electric	22 & 23	0 6 0 0 3 0	11,700 0 0
Enterprise	67	0 2 0	700 0 0
Happy Valley	3	0 1 0	350 15 0
Hessey's Waikaia	4	0 1 0	250 0 0
Inchdale	2	0 1 0	350 0 0
Lady Roxburgh	1	0 1 0	333 0 0
Mystery Flat	5	0 2 0	256 4 0
No Town Creek*	17	0 1 0	600 0 0
Olrig	8	0 1 0	347 15 0
Perseverance	18	0 2 0	1,400 0 0
Tuapeka	23	0 1 0	140 0 0
Waikaka Queen	2	0 1 0	335 10 0
Total			£18,799 9 0

* West Coast dredges.

For the month of March:—

Name of Company.	No. of Dividends.	Amount per Share.			Total.		
Blackwater River*	5	0	1	6	710	12	6
Dunstan Lead	4	0	1	0	874	7	0
Earnscleugh	21	0	1	0	550	0	0
Electric	24	0	1	6	1,950	0	0
Enterprise	68	0	1	0	350	0	0
Gabriel	3	0	1	0	257	0	0
Golden Bed	1	0	1	0	635	0	0
Golden Run	21	0	5	0	2,750	0	0
Hartley and Riley	29	0	2	6	812	10	0
Hessey's Waikaia Freehold	5	0	2	0	500	0	0
Lady Roxburgh	2	0	1	0	333	0	0
Ladysmith	2	0	1	0	510	0	0
Nelson Creek*	24	0	2	0	850	0	0
Olrig	9	0	1	0	347	15	0
Total					£11,430	10	6

* West Coast dredges.

An interesting feature in this field is the improvement in the treatment of black sands.

"These gold deposits, consequent upon marine action, occur in places stretching over some hundreds of miles along the coast line. . . . It has been made manifest that black sand when mixed with a reasonable proportion of beach shingle can be dealt with in bulk by a bucket dredge of the ordinary type in a successful manner (North Beach Company's success); and I am of opinion that where sufficient area is available to afford a dredge, say, 10 years' work, and it is proven that there is a reasonable proportion of gold existing, the local claims will prove more profitable, on the whole, than the claims situated in creeks and watercourses, where work is liable to more frequent disturbance, and where the gold deposits appear to be more patchy."—("New Zealand Report on Minerals and Mines," 1903, p. 156 *seq.*)

"All black sand beaches are at present commanding considerable attention. . . . The prospects obtained warrant the erecting of dredges specially designed to deal with black sand. . . Our experience of dredging has not been very satisfactory . . . mainly owing to light and defective machinery and the depth and tightness of the material. . . . In this respect our sea beaches are more likely to pay for working."—("New Zealand Report on Minerals and Mines," 1903, p. 161.)

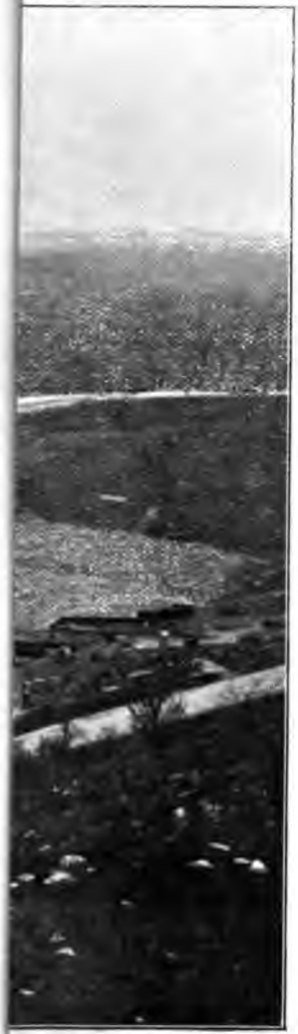
Nicaragua.—"Along the Coco River, which empties itself into the Atlantic, there is some placer mining being conducted by English and Americans."—("Mining in Nicaragua." By H. E. West. "Mining & Scientific Press," June 18, 1904, p. 409.)

Oregon.—"The scene of greatest activity in dredging operations in the State of Oregon has been upon Snake River, the bars of which, for practically the entire length of the stream carry values in gold. . . . The dredging industry in Oregon is doubtless in its infancy, as many locations are yet available which can be made to yield profitable returns by this method of mining."—("Mining & Scientific Press," May 14, 1904, p. 328.)

Philippines.—The Inspector of Mines at Manilla, Senor Luis Espina, in 1898, said: "Gold is found in moderate quantities nearly all over the Island of Luzon, but more particularly and under conditions favourable for exploitation, in the Provinces of Bontoc, Lepanto, Benguet, Nueve Ecija, Ambos Camarines, and Abra. In Lepanto it is found in veins, alluvial deposits and in river sands. It is of a light colour and of a degree of fineness to 0.833. In the Province of Nueve Ecija, the gold is exceedingly pure, brilliant in colour and 0.958 in fineness. In Abra, it is found in alluvial deposits and in river sands."—("Mining in the Philippines." "The Mining World," Chicago, July 30, 1904, p. 100.)

Scotland.—"The gold of the Leadhills area is found in the streams into which it has been washed from a gravelly clay, locally known as 'till,' which lies disposed on the slopes of the hills. The gold generally occurs as fine dust, but small nuggets of varying size have, from time to time, been observed. . . . The Suisgill and Kildonan streams in Sutherland, also, are auriferous, and in 1869 no fewer than 400 men are said to have been employed in the diggings. Alluvial gold has also been reported in Perthshire."—("Gold in Great Britain and Ireland." By J. M. Maclaren. "Trans. Inst. of Mining Engineers," Vol. XXV., Part 4, p. 455 *seq.*)

Servia.—"It may be interesting to chronicle the operation of the first dredging machine in Europe, and also the discovery of large areas of gold-bearing alluvions, with favourable conditions of climate, labour, and transport, which, in the near future, may afford a most profitable field for investment. . . . The result was my discovery that the principal value of the concession . . . was a very large area of gold-bearing gravels in two large and well-defined basins, some two miles long by one broad, of former lake origin, but now connected by a river flowing to the Danube, whose tributary mountain streams contain a considerable amount of gold, which is worked by



Holland.

nd one under erection. 170—A

the peasants to a small extent by panning, when they are not engaged in agricultural pursuits. The origin of the gold appears to be the erosion of crystalline schists and granites containing auriferous veins. The gravels and some of the quartz veins were worked by the ancient Romans, as evidenced by many interesting remains of gold and other coins, and of jewellery of the reigns of Constantine, Justinian, B.C. 451, and of old bronze mining tools, and other curiosities unearthed from time to time in the district, which was mentioned in Pliny's History. A thorough examination of the gravels was subsequently made by me with an American drilling machine as used in California, &c., the results showing a payable amount of gold over a large area, with favourable conditions of clean gravel, water, fuel, cheap transport, labour, and climate for dredging, and I may here state that I have opened a fine deposit of lignite coal, three yards in thickness, since the concession was taken over by our company, which provides fuel for the dredge. Within twelve months, a dredge of 1,000 cubic yards per twenty-four hours capacity, of European construction, built by a Dutch firm of note* on New Zealand lines, was erected, and is now at work on a profit-earning basis under my management, and may prove (as named) the 'Pioneer' of a profitable industry in Europe."—(" The First Gold Dredging in Europe." By P. B. Weston. " The Mining Journal," November 14, 1903.)

Shan States.—" It is believed that the country is rich in minerals, and no fewer than fifteen applications for prospecting licenses were received during the year. Gold is principally sought for, but no paying reefs have yet been discovered. The washing of alluvial deposits in the valley of the Nam River is, however, being undertaken by a Rangoon firm, and this experiment will be watched with interest." —(Extract from Report on the Administration of the Shan States in 1903—4, *see* " The Mining Journal," January 28, 1905.)

Siam.—" Gold is very widely distributed in Siam; and is washed out of the alluvium by the natives in several districts. The chief of these are Pu Kiriu, Bangtaphan, Kow Suplu, and Tomoh. In the latter district, Chinese workers carry on lode mining as well as alluvial. The native gold mining industry is, however, a very unimportant one; the total number of persons regularly employed probably not exceeding one thousand. Gold mining according to modern methods has been far from successful in Siam. This may be accounted for, partly by the difficult nature of the country for carrying on mining by Europeans, and partly by bad management; but it remains to be seen whether the future will bring forth better results."—(" A Note on Mining in Siam." By H. G. Scott, A.R.S.M., Director of Mines and Geology, Bangkok. "The Mining Journal," August 20, 1904, p. 185.)

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* This dredge was built, in 1903, by the Shipbuilding & Engineering Company, Limited, Werf Conrad, of Haarlem, Holland. This order was soon followed by a second; both dredges are now working on the Rex River, Servia. An order for a third dredge, of similar capacity, is now in course of execution by the same firm.

Siberia.—"The introduction of gold dredges began four or five years ago. The country contains many placers well suited for working by these methods. . . . Dredging in Siberia has given, so far, very favourable results, and it is unquestionably destined to become of importance. . . . The richness of placers in Siberia is measured by the gold (weighed in doles) contained in 100 poods (3,630 lbs.) of ground, the usual estimate being that a cubic sagen (about 13.08 cubic yards) is equal to 1,000 poods. Practice and calculation have determined the following contents as the minima that will pay costs, but give no profits. The contents are based on 100 poods (1.3 cubic yards) of ground of the whole placer; that is to say, of gold-bearing gravel and of barren muck taken together. Naturally, figures vary considerably in different localities, and it is necessary to consider only those which apply to ordinary conditions in Siberia. The figures are as follows: Work by hand pays expenses with a yield per 100 poods of 10.16 doles (30.97 cents); dredging, 3.7 doles (10.9 cents); an excavator, 1.8 doles (5.3 cents). These figures show that when hand labour cannot make a profit, a dredge can give brilliant results. The results for machinery would be still more favourable, if there were less water, and it were possible to put in excavators. In fact, the future of the gold industry in Siberia may be summed up in two words—dredge and excavator."—(" Gold Dredges in Siberia." By A. Foniakoff. "The Engineering & Mining Journal," June 9, 1904, p. 917.)

Spain.—Before 1100 B.C. the banks of the Guadalquiver were worked for alluvial gold, and some time before 500 B.C. the auriferous deposits of Spain were believed to be exhausted. But Pliny records that in 207 B.C., when the second Punic war ended in the Roman conquest of Spain, 'Some have related that Asturias, Gallicia, and Lusitania furnish 2,000 lbs. weight of gold 4,427 lbs. English weight) annually, but Asturias supplies the most, nor in any other part of the world during so many ages has so great a quantity been obtained.'

"During the eight centuries that the Arabs were masters of the Peninsular, they prosecuted their exploration for the precious metals with great vigour. They worked the gold mines at Lares, they washed the sand of the Douro, the Darro and the Guadalquiver for gold, and they left in the hills of Jaen more than 5,000 shallow pits, as the result of five centuries of gold mining in that district. But, as your correspondents have pointed out, the Romans washed for gold over a larger area and on a much larger scale than the chroniclers of the time were aware of. Even Jacob in 1831 was unaware of the extent on which their operations were conducted, for modern investigation had disclosed that in the provinces of Lugo and Orense and Leon many of the rivers were washed by the ancients on an immense scale. So profitable must the operations have been that, as your correspondent 'A. V. S.' points out, in one case the River Sil was diverged out of its course by means of a cutting made through a mountain spur in order that the river bed might be exposed for the precious metal. Considering the primitive means that the Romans possessed, this must be regarded as a gigantic engineering feat, and it has been estimated that if 10,000 men had been engaged on the work it would have taken many years to complete.

"In the case of other alluvial properties, water was brought in from great distances by canals, and at Paramo, in Leon, the ancient water channels are now used as country roads. Many of these water-races were so substantially constructed that they could be repaired at a comparatively small cost. Where these indications of previous workings are observed, gold has always been found, and in the summer, when the river channels narrow under the influence of the sun, the banks of the Ouria, the Navia, the Sil, and their tributaries, and all the considerable rivers of these North-West provinces, are panned by the country people, who get a very good return on their labours. Yet the fact remains that while the existence of gold in highly-paying quantities has been definitely proved, no systematic exploitation of this rich source of auriferous supply has yet been attempted. In New Zealand scores of locally floated gold dredging companies are reaping rich and regular returns on a comparatively trifling outlay; in New South Wales and Victoria gold dredging has been carried on for years with most satisfactory results, and in California, alluvial mines worked by hydraulic sluicing methods give handsome profits from alluvial carrying only about 4 grains of gold per cubic metre. In Australia where the water has to be pumped, the cost of treating the alluvial does not exceed 6d. per ton.

"The cheapness and profitableness of working gold-bearing alluvial has been demonstrated still more recently in British Columbia, where a large amount of money is embarked in the enterprise and splendid returns are being obtained. But Spain offers more substantial inducements to the gold washer than any of these countries. The alluvials of the peninsula are richer, their situation renders them extremely accessible, and although the process of obtaining a transfer of properties and the alluvial rights is complicated, the difficulties are by no means insuperable, and, having obtained the necessary transfer, the rental and royalties are very much less than those demanded in Russia and Australia and British Columbia, and the cost of labour is comparatively insignificant. Roughly speaking, labour in Spain works out at one-fifth of the rate that is paid in Australia and Zew Zealand. The difficulties of complying with the legal provisions in obtaining the transfer of alluvial concessions has been greatly exaggerated, while the facilities that obtain for working and treating the alluvial do not appear to be fully appreciated.

"During the past few months no fewer than 33 groups of alluvial claims have been acquired by English capitalists in the provinces of Leon, Orense, and Lugo. The mineral and geological features of the foregoing properties are common to them all, and wherever the alluvial is gold-bearing, in this part of the country, their characteristics are singularly uniform. The depth of the deposits varies from 10 ft. to 25 ft., and the proportion of untreatable matter in the form of stones and boulders also varies, but, if 50 per cent. be deducted on this account, an enormous balance of ore still remains. Samples of deposits from all parts of the properties give a minimum return of 5 dwts. of gold per cubic yard, and the washing machines adapted for the purpose, which cost about £25 each, are capable of treating 25 cubic yards per diem at a cost of from 3½d. to 6d. per cubic yard. At Paramo, the alluvial is being worked by these machines with the most satisfactory results, and similar machines will shortly be at work on the Kingston alluvial gold mines in Leon and the alluvials of the Moraleja gold-bearing alluvial concession in the province of Orense. If the deposits, instead of returning 5 dwts. of gold to the cubic yard, only yield 1½ dwts., the profits will still be enormous, and by multiplying the machines—which can be erected and put in operation within twenty-four hours of the time of their delivery on the property—the output can be increased almost indefinitely.

"For many months, these sandy alluvials can be worked in this manner, the capital required being only the expense of the machines and the cost of labour. When the alluvial is exhausted down to water level, the beds of the rivers will have to be dredged. Up to the present time, these river deposits have not been touched, and they will, of course, be found to be considerably richer in gold than the exposed alluvials. By many mining men the results of the dredging operations are looked to to bring about the revival in Spanish mining that has been so long hoped for. It is impossible to contemplate the probable—one might almost say the assured—return from this dredger mining without a feeling of amazement that such a source of wealth should have lain so long untapped. Want of capital in Spain and want of confidence in the Spaniards have hitherto been the chief obstacles to her progress, and the fact that the country has never become a fashionable mining venue has also to be taken into consideration in reviewing the causes that have contributed to its backward position. It is, however, evident to those who have been much in the country in recent times that the long-delayed interest in its mineral resources has set in, and it is with considerable confidence that one predicts an enormous revival in the industry as soon as some of these alluvial gold-bearing districts are systematically exploited and regular returns are forthcoming."—(" Alluvial Gold Mining in Spain." By A. F. Calvert. " The Mining Journal," December 6, 1902.)

United States.—" Gold dredges are operating successfully in the United States in Oregon, Idaho, Montana, Colorado, and New Mexico. In this, our State, gold dredging has been carried to its highest development. At Oroville there are 26 dredges operating. There are from 5,000 to 6,000 acres of dredging land proved and developed. A conservative estimate of the value of these Oroville properties is $4,500,000. None of the stock in the companies is for sale. On the American River, near Folsom, a good dredging field has been proved. It has not been so fully developed as Oroville, but the dredging acreage is about as great as that of Oroville. There are four dredges near Folsom, and lately new life has been infused into the camp. Plans have been made to equip the properties with dredges as rapidly as possible. Two large dredges are now nearing completion, and a third is under way, and soon the Folsom district will attain the prominence of Oroville. The Yuba field promises a brilliant future, with an acreage of 3,000 to 4,000. On Bear River, near Wheatland, there is a field of over 1,000 acres, and new machines are being built to work it. On the Caleveras, at Jenny Lind, a large dredge has just been completed, and a fine return on the investments seems assured. In Siskiyou and Trinity counties, dredges are being successfully worked and soon these fields will be extensively exploited."—(" The Gold Dredging Industry." By F. C. Griffin. " Mining & Scientific Press," April 16, 1904, p. 261.)

" The gravel in the Oroville field averages about 33 ft. in depth, and in places involves hard digging, although the boulders seldom weigh over 300 lbs., and, as a rule, do not exceed 50 lbs. . . . It is very difficult to arrive at the average value per cubic yard of the entire field, but the estimate of 15 cents per cubic yard is probably fairly correct, though the values vary considerably over such a large area."—(" Gold Dredging and Prospecting." " Mining Magazine," January 1905, p. 7.)

Wales.—" After having seen the Barmouth Gold Dredging claims, I will undertake to say that with a properly constructed dredge there should have been a handsome investment for the stockholders. This may seem news to some, but there is quite a large extent of auriferous country in Wales."—(" A Few Notes on Gold Dredging." By F. S. Clarke. " The Canadian Mining Review," 1902, p. 27.)

"The alluvial gold of the River Mawddach is found mainly in the bed of the stream, but a fair prospect may be washed in many places from the soil on the slopes of the valley. . . . As a general rule, the Mawddach alluvial gold is worth about 5s. per oz. more than vein gold. . . . The earliest attempt to obtain gold from the sands of the river Mawddach was that of Mr. F. Walpole and Sir A. Webster in 1852. In 1870, owing to the unprecedented lowness of the river, several Australians and Californians worked it with good results. Above Gwyn-fynydd, no nuggets have been found, but they occur along the whole course of the River Mawddach from Rhaiddr Mawddach to Cymmer Abbey, the gold gradually becoming finer as the latter place is approached."—(" Gold in Great Britain and Ireland." By J. M. Maclaren. "Trans. Inst. of Mining Engineers," Vol. XXV., Part 4, p. 455, *seq.*)

Yukon.—" Until 1900, the steam boiler with attachments was considered the acme of modern appliances for working the mines in the Yukon, but in that year a Detroit firm decided to place a modern dredge of 700 cubic yards capacity per twenty hours on claim No. 42, below Discovery, Banonza Creek. I have no hesitation in saying that, with the immense area of auriferous land to choose from, there would be no difficulty for the engineer, conversant with the requirements of a dredge in the Yukon, to obtain perhaps one of the best dredging propositions in America to-day. .. . With the present existing facilities for gold dredging in the Yukon, and they will improve year by year, it is safe to predict that the near future will see numerous dredges in operation there, and that the yearly output of $10,000,000 worth of gold dust may be trebled or quadrupled." —(" The Opportunities for Gold Dredging in the Yukon." By E. B. Bolger. " Mining & Scientific Press," May 14, 1904, p. 332.)

XXXI.—Conclusion.

It is, perhaps, scarcely necessary to state the conclusion to which readers will probably have arrived—namely, the comparative safeness of dredging investments, made under competent advice. For, on the one hand, the costs of the dredge and equipment and of operating are now fully determined; and as, on the other hand, the value of the ground, if properly prospected, can be closely estimated, there is a certainty as to results that can rarely, if ever, be attained in other forms of mining.

Dredge Regulations.

WITH a view to the safety of persons employed on dredges, the following regulations are in force in New Zealand:—

1. Every dredge used for mining purposes shall be provided with (*a*) a life-buoy, a light-line, and a boat hook, near the bow of the dredge; (*b*) a life-buoy, a light-line, and a boat hook, near the stern of the dredge; (*c*) a boat containing a light-line and a boat hook.

2. In deep or swift-flowing streams, in addition to the above, the dredge shall be provided with not less than two boats, each containing a life-buoy, a light-line, and a boat hook. Life-belts also shall be provided, and each of the crew of any boat shall wear a life-belt when shifting the dredge moorings.*

3. All safety appliances must be kept in conspicuous places, within easy reach.

4. The dredge well-hole shall be fenced or covered as far as possible. Where this cannot be done, a moveable gangway, not less than 2 ft. 6 ins. wide, with hand-rail at each side, must be used for crossing the well-hole.

5. No person shall step on the buckets or chain when in motion.

6. All exposed gearing, belting, or machinery, must be satisfactorily fenced.

7. On every dredge not entirely covered in, the sides of the uncovered part of the hull must be fitted with stanchions, not more than 8 ft. apart, or with two strong hand-rails or tightly stretched wires or chains.

8. Every dredge working close to a bank shall be provided with a gangway of not less than 2 ft. 6 ins. wide, with double hand-rail, and properly secured to the deck.

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* The work of running lines between dredges and the banks of swift-flowing rivers is perhaps one of the most dangerous features of a dredgeman's occupation, and experience has repeatedly proved the necessity for the special rule which requires the crews of boats so engaged to wear life-belts during such operations. The capsizing of boats has occurred on several occasions and lives have been lost. The general method is to coil up the rope in the bottom of the boat, and for one man to pay it out by hand. In such rivers as the Kawaran, Clutha, and similar rapid streams the boat sometimes gets beyond the control of the oarsman to some extent, with the result that the man paying out the rope by hand is thrown overboard by a sudden jerk. To obviate this, Mr. T. Shore (dredge master of the Alpine Consols Dredge, Cromwell Gorge, Otago), designed a windlass-barrel, 9 ins. diameter, fitted at one end with a 2 ft. diameter flange, and at the other end with a hand-wheel of similar size. The whole is mounted on an angle-iron frame, which can readily be connected with and removed from the sides of the boat. The flange-wheel is provided with a powerful screw brake to regulate the speed of the boats and consequent paying out of the line, any taking up of the line being effected by the hand-wheel. The line is guided over the bow of the boat by a fair-lead in the shape of a pair of ram's horns, and designed to prevent the rope being jerked out. The appliance is stated to have worked satisfactorily and has been extensively adopted.

GOLD DREDGING COMPANIES.*

THE following is a list of the principal English-owned gold dredging companies:—

African Gold Dredging & Mining Concessions, Limited, Salisbury house, E.C. *(Gold Coast.)*

Ajaka Alluvial Mining Company, Limited, 15 Copthall Avenue, E.C. *(Gold Coast.)*

Alangoua & Comoé Gold Fields, Limited, Palmerston House, E.C. *(Ivory Coast.)*

Ankobra (Taquah & Abosso) Development Syndicate, Limited, 13 Austin Friars, E.C. *(Gold Coast.)*

Ashanti Goldfields Auxiliary, Limited, 7 Southampton Street, W.C. *(Gold Coast.)*

[As no one concern may hold more than twenty miles of concessions, the company in October 1903 registered fourteen companies, each with a nominal capital of £5,000, to acquire the dredging concessions. The titles of the concerns are:—

Ofin River Dredging Company, Limited.
Ofin & Jim Dredging Company, Limited.
Cis Ofin Dredging Company, Limited.
Jim River Dredging Company, Limited.
Ofin River Extension Dredging Company, Limited.
Atchima Dredging Company, Limited.
Atchima & Ekwanta Dredging Company, Limited.
Atchima Extension Development Company, Limited.
Ekwanta Mining & Dredging Company, Limited.
Atchima & Ekwanta Exploration Company, Limited.
Adra River Company, Limited.
Adra River Development Company, Limited.
Adra & Ofin Dredging Company, Limited.
Ghwinnie Steam Dredging Company, Limited.

The directors of these companies are also the directors of the Ashanti Gold Fields Auxiliary. The whole of the share capital was allotted to the parent company.]

Asiakwa Hydraulicking & Mining Corporation, Limited, 54 Coleman Street, E.C. *(Gold Coast.)*

Atlin Lake Company, Limited, Moorgate Station Chambers, E.C. *(British Columbia.)*

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* "Mining Journal," March 25, 1905.

Atlin Mining Company, Limited, Finsbury House, E.C. ***(British Columbia.)***

Birrim Valley Gold Mining & Dredging Company, Limited, 54 Coleman Street, E.C. ***(Gold Coast.)***

Bonanza Creek Hydraulic Mining Company, Limited, Gresham House, E.C. ***(Canada.)***

Consolidated Gold Fields of New Zealand, Limited, 20 Copthall Avenue, E.C. ***(New Zealand.)***

Denkera-Ashanti Mining Corporation, Limited, 5 Fenchurch Street, E.C. ***(Gold Coast.)***

Duff Development Company, Limited, 15 George Street, Mansion House, E.C. ***(Malay Peninsula.)***

First Rio San Juan de Oro Company, Limited, 42 Spring Gardens, Manchester. ***(Bolivia.)***

Fraser River Gold Dredging Company, Limited, 18 Southampton Street, W.C. ***(British Columbia.)***

Gold Creek Placer Mines, Montana, Limited, 10—11 Austin Friars, E.C. ***(United States.)***

Inca Gold Development Corporation of Peru, Limited, 5 Fenchurch Street, E.C. ***(Peru.)***

Jirnkee Gold Mining Company, Limited, Moorgate Station Chambers, E.C. ***(Victoria.)***

Kelantan Gold Dredging Company (No. 1), Limited, 15 George Street, Mansion House, E.C. ***(Malay Peninsula.)***

Klondyke Bonanza, Limited, 42 Poultry, E.C. ***(Canada.)***

Klondyke Consolidated Gold Fields, Limited, 9 Queen Anne's Gate, S.W. ***(Canada.)***

Klondyke Government Concession, Limited, 31 Lombard Street, E.C. ***(Canada.)***

Kyebi Lands Corporation, Limited, 54 Coleman Street, E.C. ***(Gold Coast.)***

Last Chance Creek Mining Company, Limited, 30 Bedford Row, W.C. ***(Yukon.)***

London & Canadian Explorers, Limited, 72 Gracechurch Street, E.C. ***(Canada.)***

London & Liverpool Ashanti, Limited, 7 Southampton Street, Holborn, W.C. ***(Gold Coast.)***

Manica Development Syndicate, Limited, 20 Copthall Avenue, E.C. ***(Mozambique.)***

Manica Explorers, Limited, 615 Salisbury House, E.C. ***(Mozambique.)***

Manica Gold Dredging & Mining Syndicate (East Africa), Limited, 3 Great Winchester Street, E.C. ***(Mozambique.)***

Mazoe Alluvial Gold Company, Limited, 50 Fenchurch Street, E.C. *(Rhodesia.)*

Monomotapa Development Company, Limited, 18 Austin Friars, E.C. *(Rhodesia.)*

Monomotapa Gold Dredging Company, Limited, 6a Austin Friars, E.C. *(Rhodesia.)*

Moraleja Gold-Bearing Alluvial Concession, Limited, 55 West Regent Street, Glasgow. *(Spain.)*

Namma Gold Dredging Company, Limited, *c/o* Rehder & Higgs, 29 Mincing Lane, E.C.

Nerchinsk Gold Company, Limited, 3 Crown Court, Old Broad Street, E.C. *(Russia.)*

New Zealand Mines Trust, Limited, 11 Abchurch Lane, E.C. *(New Zealand.)*

Nueva Esperanza Gold Mines, Limited, 10 Finsbury Square, E.C. *(Colombia.)*

Offin River Gold Estates, Limited, Coventry House, South Place, E.C. *(Gold Coast.)*

Omai Gold Mining Company, Limited, 60 London Wall, E.C. *(British Guiana.)*

Palenque Gold Mining Syndicate, Limited, 65 London Wall, E.C. *(Colombia.)*

Paramo Gold Company, Limited, 17 Tower Royal, E.C. *(Spain.)*

Patagonian Dredging Syndicate, Limited, 3 Princes Street, E.C. *(Patagonia.)*

Patia Syndicate, Limited, 229 Gresham House, E.C. *(Colombia.)*

Pavas Gold Mines, Limited, 14 Devonshire Square, E.C. *(Colombia.)*

Pilaya Gold Syndicate, Limited, 44 Queen Street, Edinburgh. *(Bolivia.)*

Pritchard's Gold Dredging Company, Limited, 5—6 Court Row, Guernsey. *(Africa.)*

Reeve's Gold Dredging Syndicate, Limited, *c/o* Hollams & Company, 30 Mincing Lane, E.C. *(Chili.)*

Revue (Manicaland) Gold Mining Company, Limited, Salisbury House, E.C. *(Mozambique.)*

Rica Gold Mines, Limited, 14 Devonshire Square, E.C. *(Colombia.)*

Rinconada Exploration Syndicate, Limited, 96 Bishopsgate Street, E.C. *(Argentine.)*

Roper River Concessions Syndicate, Limited, 175 West George Street, Glasgow. *(Western Australia.)*

Servian Dredging & Mining Syndicate, Limited, 52 Coleman Street, E.C. *(Servia.)*

Siberian Gold Dredging Company, Limited, 3 Crown Court, Old Broad Street, E.C. *(Russia.)*

Slough Creek, Limited, 18 St. Swithin's Lane, E.C. *(British Columbia.)*

Slough Creek Gravel Gold, Limited, 38 Broad Street Avenue, E.C. *(British Columbia.)*

Sluicing Syndicate, Limited, 76 Bishopsgate Street, E.C. *(Russia.)*

South African Gold Dredging Company, Limited, Winchester House, E.C. *(Mozambique.)*

South American Gold Fields, Limited, 792 Salisbury House, E.C. *(French Guyane.)*

South-East Africa, Limited, 84 Bishopsgate Street, E.C. *(Mozambique.)*

Surinam Gold Concessions, Limited, 7 Southampton Street, Holborn, W.C. *(Dutch Guiana.)*

Taquah & Abosso Gold Mining Company (1900), Limited, 13 Austin Friars, E.C. *(Gold Coast.)*

Timbiqui Gold Mines Company, Limited, 88 Bishopsgate Street, E.C. *(Colombia.)*

Trinity Gold Placer Mining Syndicate, Limited, 10—11 Walbrook, E.C. *(California, U.S.A.)*

Twin Lakes Placers, Limited, 5 Laurence Pountney Hill, E.C. *(United States.)*

Upper Ankobra Dredging Syndicate, Limited, 7 Southampton Street, W.C. *(Gold Coast.)*

Vermilion Forks Mining & Development Company, Limited, 7 Great St. Helen's, E.C. *(British Columbia.)*

Vital Creek (B.C.) Mining Syndicate, Limited, Portland House, Basinghall Street, E.C. *(British Columbia.)*

Westland Dredging & Sluicing Company, Limited, College Hill Chambers, Cannon Street, E.C. *(New Zealand.)*

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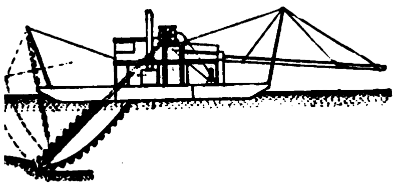

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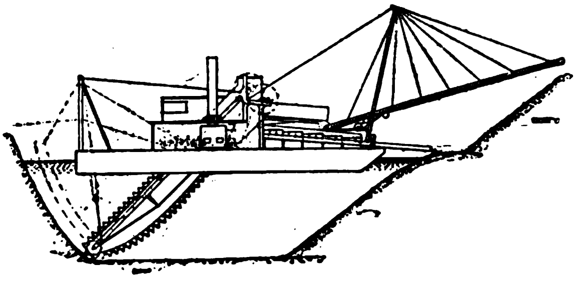

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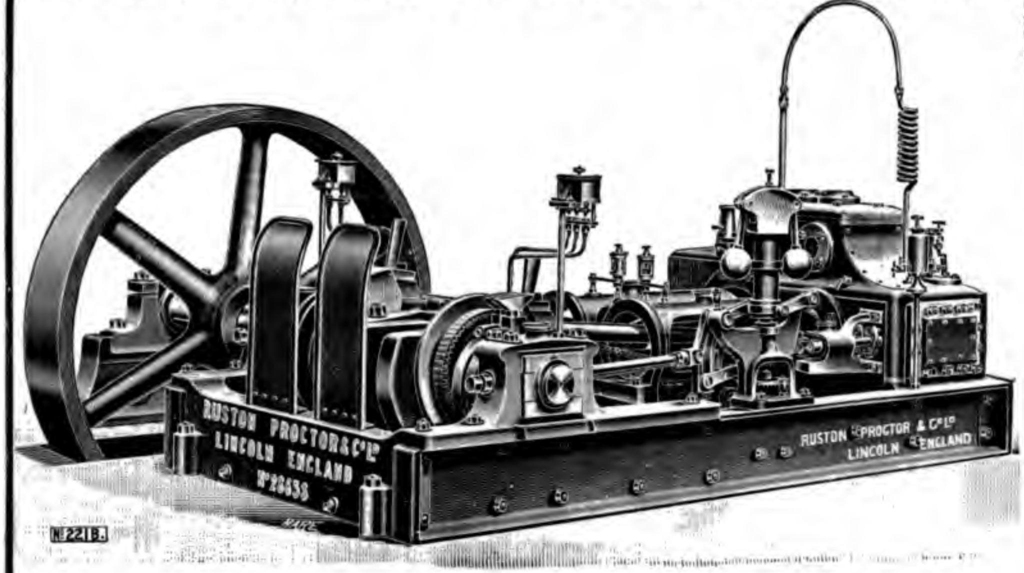

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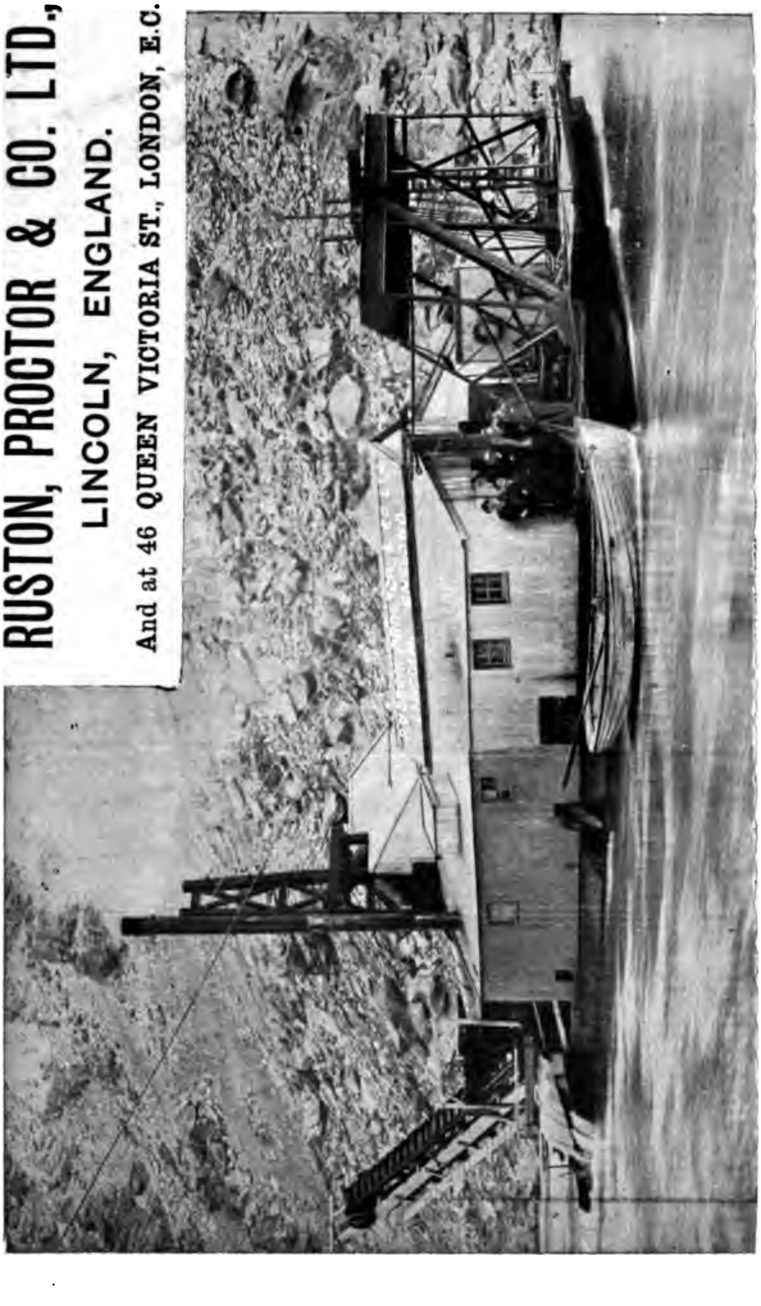

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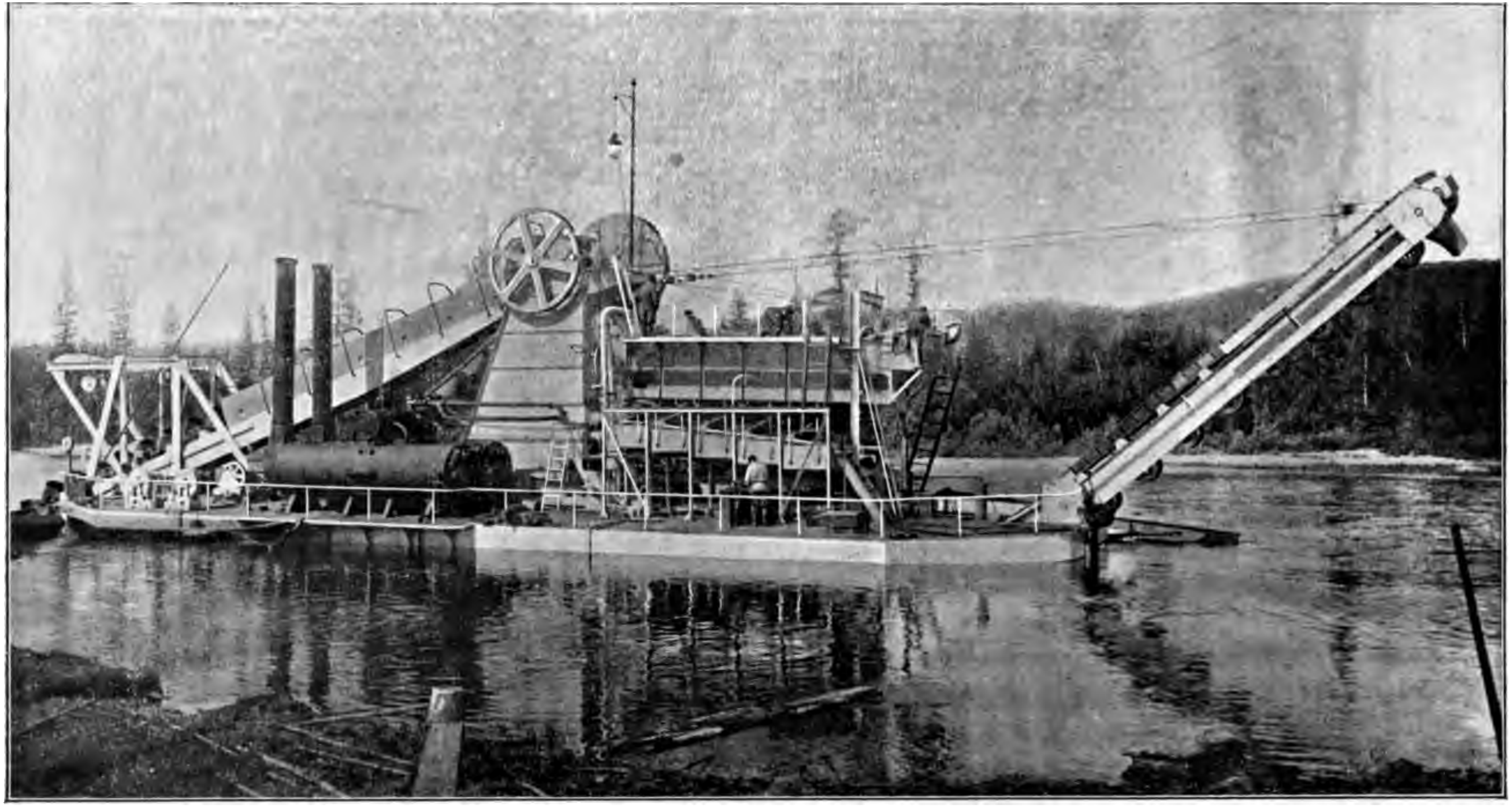

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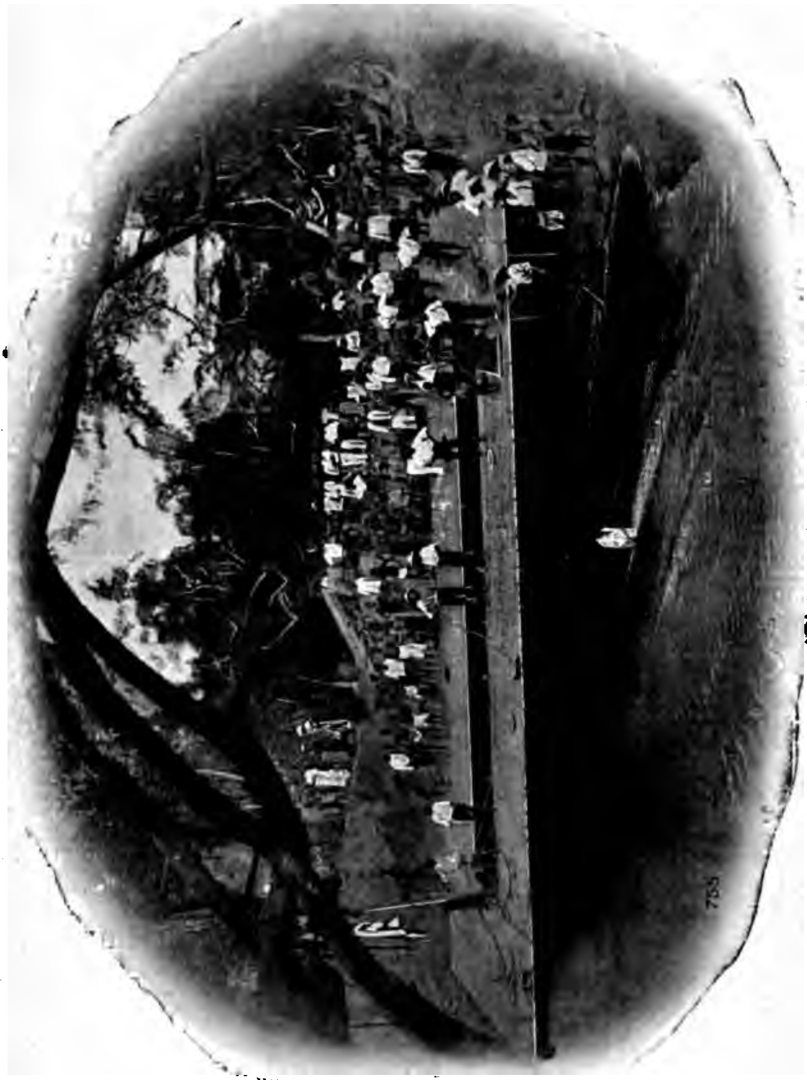

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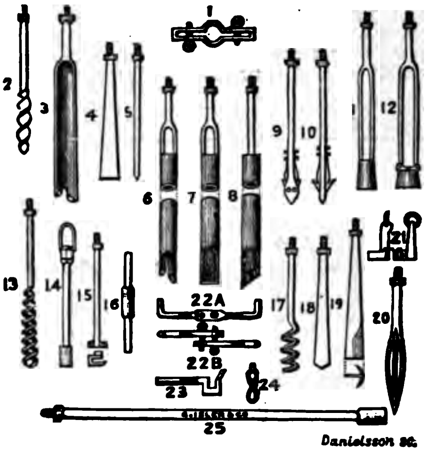

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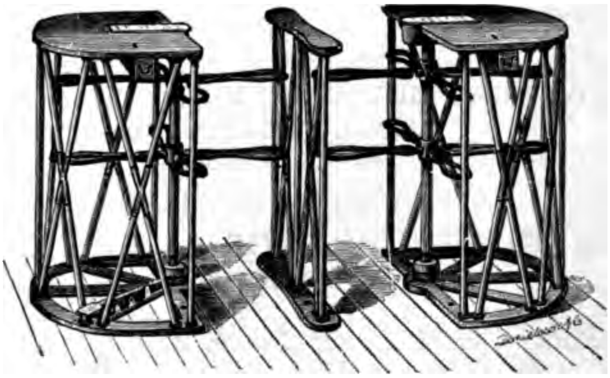

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